INDIA'S ENERGY USE PATTERN: A STRUCTURAL DECOMPOSITION ANALYSIS IN INPUT-OUTPUT FRAMEWORK

A Thesis Submitted

in Partial Fulfillment of the Requirements

for the Degree of

DOCTOR OF PHILOSOPHY

by

Umakant Dash

to the

DEPARTMENT OF HUMANITIES AND SOCIAL SCIENCES

INDIAN INSTITUTE OF TECHNOLOGY, KANPUR

September 1996.

CERTIFICATE

27.9.96

It is certified that the work contained in the thesis entitled **"INDIA'S ENERGY USE PATTERN: A STRUCTURAL DECOMPOSITION ANALYSIS IN INPUT-OUTPUT FRAMEWORK"** by Mr. Umakant Dash has been carried out under my supervision and that this work has not been submitted elsewhere for a degree.

(K. K. Saxena)
Professor of Economics
Department of Humanities & Social Sciences
Indian Institute of Technology, Kanpur

September 1996.

CERTIFICATE

This is to certify that Mr. Umakant Dash has satisfactorily completed all the courses requirements for the Ph.D. programme in economics. The courses include:

Eco 737	DEVELOPMENT ECONOMICS
Eco 739	PRICE THEORY
Eco 740	INTER-INDUSTRY ECONOMICS
Eco 741	PROJECT ECONOMICS
Eco 745	MONETARY ECONOMICS
Eco 746	INTERNATIONAL ECONOMICS

Mr. Umakant Dash was admitted to the candidacy of the Ph.D. degree in August 1993 after he successfully completed the written and oral qualifying examinations.

Head

Department of Humanities

and Social Sciences

Convenor

Departmental Post-

Graduate Committee

SYNOPSIS

Name: **Umakant Dash** Roll No. **9210066**
Degree for which submitted: **Ph.D.**
Department: **Humanities and Social Sciences**
Thesis Title: **India's Energy Use Pattern: A Structural Decomposition Analysis in Input-Output Framework.**
Name of Thesis supervisor: **Prof. K.K.Saxena.**
Month & Year of Thesis Submission: **September 1996.**

The development of an economy from a predominantly agrarian to a modern industrialised one like India has necessitated marked changes in the structure and functioning of internal economic activities. With these changes, the amount of energy required in the country which is a cumulative product of millions of decisions like the consumer deciding what to consume, the government making budget decisions, the investors evaluating where to invest, the trade representatives negotiating tariff structure, the managers choosing a production technology etc. also changes. These decisions affect what to consume(final demand) and how to produce(production technology), which ultimately determine the nation's aggregate demand for energy.

This dissertation presents an analysis of energy sectors in the Indian Economy during the period 1979-80 to 1991-92. For rapid economic development of India a comprehensive strategy for the energy sector, which is one of the major constraint, has to be evolved and for this an efficient planning is needed. The first requirement of such planning is to understand the structure of the economy as comprehensively as possible. This study is an effort in this direction. The selection of the period 1979-80 to 1991-92 for the purpose of the study was dictated by the availability of data from the secondary sources.

The empirical data for this study was provided by the Indian Input-Output tables prepared by the Planning Commission for the years 1979-80, 1984-85, 1989-90, and 1991-92. In addition, this study also used supplementary data on energy and employment collected from different sources. The analysis presented in this study can best be described as comparative static analysis and was carried out within the context of the static open I-O model. For purpose of this study the energy intensity is defined as the direct and indirect energy required to produce a single unit of output for the final demand purpose, while structural change was referred to as the analysis of change in production structure, changes in the technology used in the production process and an analysis of changes in final demand.

Before these analysis were undertaken, however, a number of adjustments were made to the I-O tables to improve the comparability of the data. These adjustments involved the aggregation of selected industries to bring all the tables to a standardised 46 sector classification, and the adjustment of the 1979-80, 1984-85, 1989-90, and 1991-92 tables to the constant price level of 1984-85. Hence the 1979-80 table was inflated to 1984-85 price level while that of 1989-90 and 1991-92 were deflated to the same 1984-85 price. As far as the data relating to energy are concerned, those were all converted to a single unit namely, Million Tonnes of Oil Equivalent(Mtoe). In spite of these adjustments to the I-O tables, a certain degree of incomparability remained and the results of this study must be interpreted accordingly.

The orientation of this study was to bring together and empirically test the methodology of energy analysis and the structural decomposition analysis(SDA) in the I-O framework by using the available Indian I-O tables. That is, the two strands viz; methodology and empirical data run side by side throughout the study equally importantly. The energy intensities which include both the direct and indirect energy requirements to produce one unit of output, were examined for the 46 sectors for

the four reference years, i.e. 1979-80, 1984-85, 1989-90, and 1991-92 for which the I-O tables were available. In this piece of study we have used the 'Hybrid Units' formulation as developed by Bulard and Hereendeen. The basic distinguishing feature under this formulation is that the monetary flows in the energy rows of the usual transaction matrix are replaced with the physical flows of energy. Thus in the revised transaction matrix we have a mix of units and the basic advantage of this model is that it conforms with the energy balance condition.

For the changes in the energy use/requirement, the sources of growth measured the contribution of factors like changes in I-O coefficients, changes in the level of final demand, and changes in the interaction factor(s) to any increase in the energy uses/requirements. While for the SDA of energy cost, the sources of growth measured the contribution of factors like changes in I-O coefficients, changes in the level of value added and changes in the interaction factor(s) to the change in the energy cost. This study is an improvement over existing studies in the sense that it measures the interrelationship of the effects of changes in the final demand and changes in I-O relations on changes in case of SDA of energy use changes. Besides as far as change in energy cost share is concerned, this study measures the interaction effect of value added and technology which is also neglected in the past. This interrelationship has been called the interaction factor(s) in this study which are ignored in most of the existing studies in the literature. Further, this study deals with the empirical investigation of changing energy cost structure of industries, where energy is treated as primary value added besides the land, labour and capital. This aspect too has been given less importance in the past studies.

The results showed that the sectors with high energy intensity were that of the manufacturing sectors, for instance, fertilisers, cement, iron & steel, non-ferrous metals, other non-metalic mineral products, leather & leather products, plastic products, and transport services while the sectors with low

intensity were communication, other services, wood & wood products, and primary sectors(except cereals). Further, the results showed that the intensity had increased over the period in sectors like agriculture(where it is basically due to the energisation of agricultural activities like pumping, tilling etc), khandsari and boora, textiles, leather & leather products, rubber products, plastic products, pesticides, etc. On the other hand, a decline in intensity was experienced in sectors like rail transport services, iron ore, other minerals, sugar, other food and beverages, wood & wood products, iron & steel, electrical machineries, rail equipments, construction etc.

The analysis of changes in energy use showed that the sectors like other non-metalic mineral products, crude oil & natural gas, petroleum products, synthetic fibre and resin, fertilisers, other textiles helped in reducing the energy requirement whereas sectors like cereals, iron & steel, other transport services, non-ferrous metals, rubber products, electricity, coal & lignite increased the energy use requirement.

The results of SDA, which is a method of distinguishing major shifts within an economy by means of comparative static changes in key sets of parameter, showed that with the change in the energy structure of Indian production which diverted from agriculture to industry, specially to heavy industries and to services and the energisation of agricultural sectors, change in the level of final demand was the most significant factor affecting the increase in output. This effect was highly significant in almost all the sectors. The contribution of the change in the composition of final demand for the entire economy was positive and relatively modest. The impact of changing I-O relation, i.e. technology effect on increase in energy use over the period under study was too small. This finding is evidence of the general stability of the underlying technological relationship as well as interdependencies among industries.

The analysis of different final demand categories showed that

the energy requirement in the Indian economy during 1979-80 to 1991-92 was largely due to the growth in the consumption demand(particularly private consumption) and investment demand.

Regarding the cost structure, the results of this study showed that the sectors with high energy share in total cost were sectors like plastic products, coal tar products, fertiliser, synthetic fiber & resin, iron & steel, non-ferrous metals, whose energy share were basically more than 20% of the total cost. Again, during this period the energy cost in the Indian economy decreased by 2.01% as compared to the base year, i.e.1979-80 cost share, which reflects the increase in efficiency of energy. Out of this total change, the most important factor responsible for the fall in the share was the technological change.

The findings of the study will help to understand the structure of the energy use in a more meaningful way. Thus, this study provides a good basis to evolve a development energy strategy for accelerated economic growth of the economy.

ACKNOWLEDGEMENTS

I wish to express my indebtedness to my thesis supervisor Prof.K.K.Saxena for all the care, affection he has shown towards me during the course of this work. He disciplined my thinking and straightened my articulation. I have discovered the pleasure and value of Economics under the guardianship of Prof. R.R.Barthwal, Prof. T.V.S.R. Rao, Prof. Binayak Rath, and Dr. Surajit Sinha.

I am thankful to Prof. B.N.Patnaik who has always been a source of inspiration and warmth. I wish to express my gratitude to Dr. B.Kamaiah of University of Hyderabad for his valuable suggestions. My sincere thanks to the H.S.S. Department staff- and to the Computer Centre officials for their timely help.

My friend Srinivasan has always been an exceptional example who has helped me in both academic and non-academic activities. I am very much thankful to my seniors Sangeeta, Sanjaya, Nagarjuna, and to my friends Sarat, Neeraj, Satyananda, Anita, Govind who have made my academic life memorable. I sincerely thank Mr S.P.Sharma for his help at all levels of the work. And I also wish to thank Ms Deepa for devoting her valuable time for going through my chapters. I am thankful to all my juniors for their support.

My life in the campus would have been a big bore without the friendship of Dandapat Sir, Debasis, Pranab bhai, Parasara, Biswajit, Mahapatra babu, Debanath, Arpita, Arbind, Niyati, and other oriya friends.

I would not have embarked on this project without the immeasurable love and patience of my mother, uncle and family members. I do not have sufficient word to express thanks to my wife Sabita, who is in fact my friend, philosopher and guide without whose support the work would have been next to impossible.

Umakant Dash

CONTENTS

List of Tables

List of Figures

CHAPTER 1

INTRODUCTION

Energy is the basic natural resource without which existence of mankind is almost next to impossible. It plays a crucial role in human welfare as besides the production factors like land, labour and capital, energy has at all times been an important basic input for the various economic activities such as production, consumption, investment, transportation and commerce. Each economic agent has always needed energy, time, information and knowledge in order to produce commodities. Hence the development and use of propitious energy sources are an essential precondition for the rapid economic development of the industrialized countries. Again, for the last two decades, starting with the 1970's the world has been confronted by a series of crisis in the field of energy viz; (i) the steep rise in the oil prices by the Organisation of Petroleum Exporting Countries(OPEC) which crippled the economies of the oil importing countries; (ii) the threat to the environment due to increase in urbanisation, rise in per capita energy consumption, felling of forest, etc; (iii) an apparent shortage of energy and the problem of global warming due to green house gas emmissions. Only in the recent past in view of the grave energy problems, economics has turned more intensively to problems of energy policy; and energy research in natural sciences has been increasingly interrelated with economic analysis. Besides from the perspective of economic and political policy makers, we have seen over the past few years energy emerges from the attention of a few specialists to attention of public and private decisions. Everyone now feels obliged to be knowledgeable about energy policy and energy analysis. From the perspective of the analyst,the changes of the last several years have moved the energy problems to the core of the most difficult analytical issues confronting society. In large measure energy policy analysis merge with the study of inflation, macro economics management, income distribution and the balance of trade.

The importance of energy economics arises from the fact that an economic system can be treated as "engine" whose input is energy and whose output is the production of commodities. The ratio of total national income to energy (or energy/GNP) is, of course, a microscopic measure which disguises variation with a system. It is also possible to look at the energy consumption within different industries or sectors of the economy and compare this to the associated value added measures in money units. Other more detailed analysis might consider an economy to be composed of 'n' interacting sectors and by virtue of an Input-Output formulation, calculate the direct and indirect energy cost per unit of output from each sectors. For the moment, however, consider the macro measure of energy/GNP which can be interpreted in several ways. One can think of it as a measure of intensity in the sense that it indicates how many units of energy are required to generate a unit of output with lower ratio implying higher energy efficiency. Secondly, the energy intensity can also be considered for a given country in order to determine whether this number is changing with time like a decreasing number might imply an increasingly energy efficient economy.

Determining that increases in energy intensity is important since there is a given relationship between energy and gross economic output. If the available energy is constrained, then an increase in a given level of economic output can be realized by reducing energy intensity and thus increasing the efficiency. However, there are thermodynamic limits to the degree to which intensity can be reduced and at the level of pragmatically attainable intensity an increase in economic growth can only come about by an increase in energy use. Much of the debate in the literature as to the future relationship between energy and economic production revolves around the potential for energy intensity/efficiency. If energy intensity can be reduced with increase in efficiency, then future economic growth can occur with less energy consumption, if not, then the "Iron Law" between energy and economic production necessitate expanding levels of energy consumption if increasing levels of output is desired.

1.1 The Energy Scene of Indian Economy.

India's performance has been fairly impressive with the gross domestic product(GDP) growing from 904 billion rupees in 1970-71 to 2123 billion rupees(1980-81 prices) in 1991-92. This corresponds to a rise in per capita GDP of over 49% during the 19 year period at an annual growth rate of 4.6%. Sectoral decomposition of GDP also changed significantly during this period. The shares of primary, secondary and tertiary sectors have changed from 46%, 22% and 32% in 1970-71 to 33%, 27% and 40% respectively in 1991-92. These changes at the aggregate level were accompanied by several compositional change within each sector. Perhaps the most notable trends include increasing mechanization of agriculture and increasing cultivation of HYV(High Yeilding Varities) of crops, faster growth of non-energy intensive manufacturing industries, and a decline in the share of passengers and freight traffic carried by railways. Such trends have resulted in substantial change in the energy demand mix. Today, in India, we have come far and have made considerable progress since planning for development started. We have achieved much, but have created potential for much more, and it is necessary to take stock of this from time to time. In case of energy it is very important not only for its role as a key to development but in a developing country like ours greater the availability of energy the more is the shortage. This is obvious from the fact that inspite of the phenomenal increase in energy production between 1950-51 and 1992-93,42 fold increase in the production of electricity, 6 fold increase in the production of coal and 30 fold increase in the production of crude oil still leaves a gap of seven percent energy shortage, 17.8 percent peak shortage and there is a need to import 26.75 million metric tonnes of crude oil and petroleum products and 4.5 million metric tonnes of coal per year.

Energy is consumed in a variety of forms in India. Fuelwood, animal dung and agricultural residues are the traditional sources of energy that continue to meet the bulk of the energy requirements in the rural India. However the traditional

"non-commercial fuels" characterized by low levels of efficiency are gradually getting replaced by commercial fuels such as coal & lignite, petroleum products and electricity.

As far as the commercial sources are concerned, India is relatively poorly endowed and the proven reserves of hydro-carbons are small, accounting for less than 6% of the global reserves. India is relatively rich in terms of coal and hydro power, but their exploitation is constrained by factors such as poor quality of coal, enviornmental concerns and inter state disputes in case of hydro power and the non-availability of financial resources. India's per capita consumption of commercial energy at 208 kg oil equivalent units is only one-eighth of the world average. While the above sources of energy both commercial and non-commercial are known as conventional sources of energy, there are three other sources of energy which are commonly called as non-conventional sources of energy. Those are solar energy, wind energy, and tidal energy. Solar power potential is unlimited in a tropical country such as India. Likewise, wind energy is abundant especially in coastal areas and in hilly regions. But both solar and wind energy are not utilized abundantly in the absence of cost effective technologies.

1.1.1 Energy Supply.

In this section we will discuss in detail the sources of commercial energy and their performance over the years. The importance of the commercial sources of energy is clear from the fact that there has been a significant change in the pattern of energy supplies with the share of commercial fuels increasing from 26% in 1950-51 to nearly 60% at present.

The primary sources of commercial energy available in India are coal, oil & natural gas, hydro and nuclear power. Even though coal dominates, persistent shortage of coal and power supply during the recent past have led to the substantial increase in the consumption of petroleum. This can be attributed to the relative ease in importing oil and petroleum products. Natural gas is

relatively new entrant in Indian energy sector and could make a significant contribution as a source of fuel and feedstock in a number of consuming sectors.

Coal.

Coal is one of the major non-renewable energy resource in India which accounts for around 58 % of the total primary sources of commercial energy. The nationalisation of the coal sector in the early 1970's marked the beginning of comprehensive programme for the development of coal mines in India. The production of coal increased steadily from 73 million tonnes in 1970-71 to 246

Table 1.1. Coal Production During 1970-71 to 1993-94.

Unit '000 tonnes

Year	Coking Coal	Non-Coking	Total
1971-72	16.75	55.67	72.42
1975-76	22.19	77.49	99.68
1979-80	23.50	80.45	103.95
1980-81	26.85	87.06	113.91
1981-82	30.25	93.98	124.23
1982-83	30.31	100.19	130.05
1983-84	30.20	108.02	138.22
1984-85	36.50	110.91	147.41
1885-86	35.65	118.59	154.24
1986-87	39.53	126.24	165.77
1987-88	41.01	138.71	179.72
1988-89	42.72	151.88	194.60
1989-90	44.43	156.46	200.89
1990-91	45.30	166.43	211.73
1991-92	46.28	183.00	229.28
1992-93	45.36	192.90	238.26
1993-94	45.06	200.98	246.04

Source: India's Energy Sector, Centre for Monitoring Indian Economy, July 1995.

million tonnes in 1993-94, with the exception of the period 1976-77 to 1978-79 when it averaged around 102 million tonnes which is shown in the Table 1.1. From the Table 1.1, it is seen that production of coal grew at a rate of 6.4% per annum during the eighties. This was a much higher rate than the 2.7% per annum increase during the sixties and the 4.6% increase during the seventies. During sixties, production of coking coal had stagnated at about 16 to 17 million tonnes per annum. Following the nationalisation of the coal industry in the early seventies, production of the coking coal increased at a faster rate of 4.2 % per annum in the seventies. This growth rate accelerated to 5.4% per annum during the eighties. Similarly production of non-coking coal has accelerated from 3.3% per annum during the sixties to 4.6% per annum in the seventies and then 6.4% per annum during the eighties. Coal production increased by 8.3% during 1991-92, and in the subsequent two years the growth rate declined to 3.5% per annum. As far as the share of coking and non-coking coal is concerned, the share of coking coal was fluctuating between 22% to 24% till 1989-90 and it started declining and reached 18.31% in 1993-94, while the corresponding share of non-coking coal was between 78% to 76% till 1989-90 and then the share started increasing and reached a level of 81.69% in 1993-94.

Crude Oil & Petroleum Products.

The development of indigenous oil industry has been an area of high priority since the mid 1970s,largely with the discovery of the Bombay high off shore. The production of crude oil rose from 6.8 million tonnes in 1970-71 to 33 million tonnes in 1990-91 and then declined continously to 27.02 million tonnes in 1993-94, after reaching a peak level of 34.09 million tonnes in 1989-90. This was largely on account of the closer of over-worked oil wells in Bombay high region. Another thing to be noted here is that, indigenous production of crude oil as percentage of the total availability which had averaged around 65% in the period 1985-90, fell to 47% in 1993-94 as a result of which the import bill of crude oil is increasing.

Table 1.2. Supply of Crude oil & N.Gas During 1970-71 to 1993-94

Unit '000 tonnes

Year	Crude oil	N.Gas
1970-71	6822	1445
1975-76	8448	2368
1979-80	11766	2767
1980-81	10507	2358
1981-82	16194	3851
1982-83	21063	4936
1983-84	26020	5961
1984-85	28990	7241
1985-86	30168	8134
1986-87	30474	9853
1987-88	30357	11467
1988-89	32040	13217
1989-90	34087	16988
1990-91	33021	17998
1991-92	30346	18645
1992-93	26950	18060
1993-94	27026	18335

Source: India's Energy Sector, Centre for Monitoring Indian Economy, July 1995.

In this subsection we would like to discuss the production and supply of the petroleum products since 1970-71. It is clear from the Table 1.3 that the production of petroleum products has increased steadily from 17.11 million tonnes to 50.89 million tonnes in 1991-92. From the table it can be seen that during the 20 years, the production of petroleum products increased by 5.1% annually, though the growth rate of eighties stood at a higher rate compared to the seventies.

The sale/consumption of Petroleum Products increased from 17.9 mt in 1970-71 to 51.08 mt in 1992-93. This was partly due to increase in economic activities. However, persistent shortages of coal and electricity, particularly during the last ten years also

Table 1.3. Supply of Petroleum Products During 1970-71 to 1993-94

Unit's in '000 tonnes

Year	Petroleum Products
1970-71	17110
1975-76	20829
1979-80	25794
1980-81	24123
1981-82	28182
1982-83	31073
1983-84	32926
1984-85	33236
1985-86	39881
1986-87	42761
1987-88	44728
1988-89	45699
1989-90	48690
1990-91	48562
1991-92	48349
1992-93	50359
1993-94	51084

Source: India's Energy Sector, Centre for Monitoring Indian Economy, July 1995.

increased the demand for petroleum products. Electric Power shortage prompted several industrial and commercial establishments to instal diesel pump sets for standby use. Furthermore, certain pricing policies, such as subsidies on kerosine, contributed to a rise in kerosine demand for household cooking thus making softcoke production unprofitable. The share of middle distillates in the consumption mix rose due to various reasons. One reason is that the Government has not allowed the price difference between kerosine and diesel to become too high. As a result, some private automobile users have preferred to retrofit their petrol driven cars by, relatively inefficient diesel engines. Other factors such as, rising share of diesel-based transport(buses,trucks and dieselization of railway engines) and increasing reliance on tractors for land preparation in agriculture, have also contributed to the growth in the share of

middle distillates in the product demand mix. From about 50% in 1970-71, their share increased to about 55% by 1980-81 and further to over 60% by 1992-93.

Electricity.

Electricity is the most convenient and versatile form of energy. Demand for it, therefore, has been growing at a faster rate than other forms of energy. Electricity sector too has recorded a phenomenal rate of growth both in terms of its volume and technological sophistication over the last few decades. It plays such a crucial role in agriculture and industrial sectors that sometimes the consumption of electricity is considered as an indicator of productivity and growth. In view of this, power development has always given a high priority in five year plans.

Table 1.4. Electricity Supply During 1970-71 to 1993-94.
Unit's ,000 GWH

Year	Hydro	Thermal	Nuclear	Total
1970-71	25248	28162	2417	55827
1975-76	33302	43303	2626	79231
1979-80	45478	56273	2876	104627
1980-81	46542	61301	3001	110844
1981-82	49565	69515	3021	122101
1982-83	48374	79868	2022	130262
1983-84	49954	86667	3546	140177
1984-85	53948	98836	4075	156859
1985-86	51021	114347	4982	170350
1986-87	53841	128851	5022	187714
1997-88	47444	149614	5035	202093
1988-89	57868	157711	5817	221396
1989-90	62116	178697	4625	245458
1990-91	71642	186546	6141	264329
1991-92	72757	208747	5525	287029
1992-93	69833	224485	6748	301066
1993-94	70375	247757	5399	323531

Sources: Central Electricity Authority, Annual Reports
India's Energy Sector, Centre for Monitoring Indian Economy, July 1995.

The Table 1.4 gives the supply of hydro,thermal and nuclear power over the years. It is clear from the Table 1.4 that the power generation increased at the rate of 12.7% per annum during the fifties. But compared to fifties and sixties, seventies registered a slightly low growth rate of 7.1%. However the growth rate again accelerated to a high rate of 9.2% during the eighties. Another interesting thing to note is that the share of hydel power has declined over the years. Hydel power capacity accounted for about 42% of the total capacity at the end of the fifth five year plan. Its share declined very sharply during the sixth five year plan. At the end of this plan period i.e. in March 1985, the share had declined to 35%. In 1994, hydel capacity accounted for only 27% of the total power generation. Though the setting up of hydel power plants is cheaper than setting up of thermal power or nuclear power plants, the major reason of the decline in the share of the hydel power plants are the hurdles in the form of inter-state disputes, ecological damage and re-location of oustees. On the contrary, the share of thermal power has been increasing over the years.

Export and Import of energy .

With the increase in the supply and demand the net import of energy has also been substantial for the last two decades. However, as the import and export of coal and electricity is not substantial in nature, we cover only the trade of crude oil and petroleum products. India is a net oil importer and its oil import has increased substantially during the past two decades. From less than 9% of foreign exchange earning through commodity export during 1960s, the net oil import bill increased to over 30% in 1973-74(following the first oil shock), and then to over 75% in 1980-81, an increase which largely stemmed from the sharp hikes in inter- national prices of oil. This occured despite an increase in relative self sufficiency in oil supplies, from a mere 6% in 1960-61 to over 30% during 1970s. Although the net oil import bill is reported to have reduced substantially since 1980-81,

Table 1.5. Import and Export of Oil and Petroleum Products 1970-71 to 1993-94 ('000 tonnes)

Year	Net Import (Crude Oil) Quantity	Rs Crore	Net Import (Petroleum Products) Quantity	Rs Crore
1970-71	11683	107	752	25
1975-76	13624	1052	2048	190
1980-81	16248	3349	7253	1910
1981-82	14460	3540	4829	1438
1982-83	12397	2980	4233	1420
1983-84	10445	2310	2856	914
1984-85	7164	1867	5159	1660
1985-86	14616	3552	1902	764
1986-87	15476	2120	556	242
1987-88	17732	2986	739	375
1988-89	17815	2861	4200	1036
1989-90	19490	4089	3971	1559
1990-91	20699	6118	6012	3656
1991-92	23994	7820	6509	4003
1992-93	29247	10686	7564	4753
1993-94	30822	10689	8042	5533

Source: India's Energy Sector, Centre for Monitoring Indian Economy, July 1995.

which is largely due to; (1) rapid increase in indigenous crude production, as self sufficiency in oil supplies increased to over 60% by 1983-84, and (2) weak oil prices in international market. In 1993-94, the import of oil and petroleum products constitute 26% of the total export earning. As it is clear from the Table 1.5 that in absolute quantity of the crude oil imported was 11683 thousand tonnes in 1970-71 which increased to 15476 thousand tonnes in 1986-87 and further to 30822 thousand tonnes in 1993-94. On the other hand the import of petroleum products had increased steadily from 752 thousand tonnes in 1970-71 to 4233 thousand tonnes in 1982-83. Thereafter it fluctuated till 1989-90 when the import was 3971 thousand tonnes. During the nineties it increased steadily and reached a level of 8042 thousand tonnes in 1993-94.

In order to measure the aggregate changes in energy consumption or production, it is necessary to express the various constituent forms of energy in terms of common units of measurement. The Energy Survey Committee of India in its 1965 report initiated the practice of measuring common unit in different fuels specified as Million Tonnes of Coal Replacement(MTCR). The coal replacement measure is the amount of coal which would be required to replace the other energy sources in use. Because of different degrees of thermal efficiencies with which the alternative energy sources are used in India, Coal Replacement Measure was considered to be more suitable. The Fuel Policy Committee(1974) and Working Group on Energy Policy(1979) have selected to use the MTCR units.

However, now-a-days, Oil Equivalent units are widely used all over the world. Since the coal replacement units certainly does make international comparison difficult, Oil Equivalent units based on International and British Petroleum Statistical Conversions are recommended for India. Hence for the purpose of consistency we have made use of the later one. The conversions of the various forms of energy into oil equivalent units have been displayed in the Table 1.6.

Table 1.6. Conversion Factors for Different Fuels

Fuels	Conversion Factors
Coal	1 mt = 0.490 mtoe
Natural.Gas	1 mm = 0.856 mtoe
Hydro Power	12000 gwh = 1.000 mtoe
Nuclear Power	12000 gwh = 1.000 mtoe
LPG	1 mt = 1.059 mtoe
Naptha	1 mt = 1.029 mtoe
Mogas	1 mt = 1.029 mtoe
ATF	1 mt = 1.020 mtoe
Kerosene	1 mt = 1.020 mtoe
HSD	1 mt = 1 000 mtoe
LDO	1 mt = 1.000 mtoe
Fuel oils	1 mt = 0.956 mtoe
Other pet.pro	1 mt = 1.000 mtoe

Source: Tata Energy Data Directory and Yearbook, 1994-95.

Several assumptions have been made in compiling these energy balances. For instance, the same average calorific value of coal is used in converting coal tonnage to Mtoe units although it is known that, with the increase in the share of open-cast mining that occured in the 1980s, the average calorific value has decreased. This assumption has to be made because detail data about the average calorific content of various grades of coal that are mined each year are hard to come by. Furthermore the discrepancy between claims of quality of coal despatched and that received by certain major consumers (particularly industry) has also not been accounted for. It is assumed that the average calorific value of steel-grade supplied for thermal power generation is 4000 kcal/kg. As the tonnage of coal supplied to the power sector is also known, we have enough information to compute the Mtoe of coal supplied to this sector-likewise for the transport sector(railways), where tonnage is known, the calorific value is assumed to be 4000 kcal/kg. With this information, the Mtoe value of coal used in other sectors is determined. It must be noted that coal consumed in the industrial sector includes coaking coal as well as coal as feedstock.

As with coal, it becomes necessary to make some assumption regarding the calorific content of natural gas. Here, the standard norm of 856.8 toe/million cubic meters of gas, as adopted by the oil industry, is used. However, this does not pertain to lean gas [after LPG(liquified petroleum gas) extraction]. To estimate the Mtoe value of gas after LPG extraction, the product of tonnage of LPG and calorific value of LPG is subtracted from the overall natural gas mtoe value. Owing to the difference in quantities of LPG extracted from year to year, this procedure gives a different value each year for average calorific value of gas remaining after LPG shrinkage.

In the power sector, it is assumed (for the sake of consistency) that conversion efficiency of hydro and nuclear power plants is the same as that of coal based thermal power plants.

This is the standard practice in constructing energy balances. The auxiliary consumption of various types of power generating plants is assumed to be as follows: (1) 10% of gross generation for coal based thermal and nuclear power station; (2) 10% for diesel power plants; (3) 2% for gas turbine units, and 0.5% for hydropower plants. These norms are average figures derived empirically from past data. The data on petroleum products for power generation are as given in the official statistics of the Ministry of Petroleum and Natural Gas. Soft-coke and kerosene are not confined to the residential sector alone, those are put to other uses also. However, such disaggregated data are not available. National Council of Applied Economics Research(NCAER), India, conducted a detail survey in 1978-79, the result of which indicated that 37% of the soft-coke and a little over 16% of kerosene is consumed in commercial establishments. The same norm has been assumed in the energy balances. And, finally, as far as stock changes are concerned, data are available only for coal and not for crude oil and refined products. Therefore, estimates of changes in stock of these items have been arrived at by subtracting exports and sales/consumption from indigenous production and imports. The overall supply of primary sources of commercial energy in common units from 1970-71 to 1993-94 has been shown in the Table 1.7.

Probing into the Table 1.7, it is found that, in the year 1970-71, coal & lignite was the principal source of energy. About 62.91% (i.e. 37.41 Mtoe) of the total primary commercial energy consumption was met solely by coal & lignite. But over the period, its share in the total energy supply went on decreasing till 1983-84 when it was 57.78% (67.90 Mtoe). However, it increased to 58.72% in 1984-85 and thereafter it fluctuated between 56 - 58% during the late eighties. During 1994-95 the supply of coal & lignite was 137.93 Mtoe, the share being 62.91%. This increase in the share of coal & lignite supply may be due to the following reasons. Firstly, increase in the numbers and generating capacity of thermal power station/plants; and secondly, hike in oil prices during the late 1970's and 1990's in the international oil market compelling the consumers to make the use of alternative fuels like coal.

Table 1.7. Supply of Primary Sources Energy from 1970-71 to 1991-92.

Unit MTOE

Year	Coal	Oil	N.Gas	Hydro	Nuclear	Total	Con'ion loss	Net Supply
1970-71	37.41	18.51	1.24	2.1	0.20	59.46	10.21	49.10
	(62.91)	(31.12)	(2.08)	(3.54)	(0.34)	(100)		
1972-73	39.96	19.41	1.34	2.27	0.09	62.46	14.39	54.08
	(65.06)	(28.50)	(2.62)	(3.59)	(0.28)	(100)		
1980-81	58.47	26.76	2.02	3.88	0.25	91.38	23.85	68.76
	(63.99)	(29.28)	(2.21)	(4.24)	(0.27)	(100)		
1981-82	64.15	30.65	3.3	4.13	0.25	102.48	26.56	74.84
	(62.6)	(29.91)	(3.22)	(4.03)	(0.25)	(100)		
1982-83	67.84	33.46	4.23	4.03	0.17	109.72	28.55	80.47
	(61.82)	(30.49)	(3.85)	(3.67)	(0.15)	(100)		
1983-84	71.48	36.47	5.11	4.16	0.30	117.51	31.26	83.68
	(60.82)	(31.03)	(4.35)	(3.54)	(0.25)	(100)		
1984-85	76.37	36.15	6.20	4.48	0.34	123.56	34.99	86.51
	(61.81)	(29.26)	(5.02)	(3.63)	(0.28)	(100)		
1985-86	80.7	44.78	6.97	4.24	0.42	137.14	38.03	93.39
	(58.86)	(32.66)	(5.08)	(3.10)	(0.30)	(100)		
1986-87	87.04	45.95	8.44	4.48	0.42	146.33	40.92	100.26
	(59.48)	(31.40)	(5.77)	(3.06)	(0.29)	(100)		
1987-88	95.1	48.09	9.82	3.95	0.42	157.38	47.65	101.58
	(60.42)	(30.56)	(6.24)	(2.51)	(0.27)	(100)		
1988-89	103.89	49.85	11.32	4.82	0.49	170.37	52.62	110.98
	(60.98)	(29.26)	(6.65)	(2.83)	(0.28)	(100)		
1989-90	106.92	53.58	14.55	5.17	0.39	180.61	64.94	114.98
	(59.2)	(29.67)	(8.06)	(2.86)	(0.21)	(100)		
1990-91	113.54	53.73	15.42	5.96	0.52	189.17	63.02	124.56
	(60.02)	(28.40)	(8.15)	(3.15)	(0.28)	(100)		
1991-92	123.12	54.37	15.98	6.05	0.46	199.97	63.03	130.62
	(61.56)	(27.19)	(7.99)	(3.03)	(0.23)	(100)		

Note: 1. The figures in the parenthesis indicate the percentage share

2. Net supply: Total supply minus conversion losses minus stock changes.

Source: India's Energy Sector, Centre for Monitoring Indian Economy, July 1995.

The share of oil in total primary commercial energy supply was 31.12% (18.51 Mtoe) in 1970-71; it has increased to 32.66% (44.78 Mtoe) in 1985-86. Then it started declining till 1994-95 when it was 26.45% (58.00 Mtoe). The increase in the share during the first half of 80's was due to the substantial increase in the indigenious production while in the late 80's and early 90's the decline in share was attributed to the Gulf crisis and increase in oil prices.

Although, the consumption of primary electricity has increased rapidly during 80's, the compound annual growth rate being 7.6%, as compared to fossil fuels, its share in total primary energy supply was only 3.88% (2.30 Mtoe) in 1970-71 which went upto 3.91% (4.82 mtoe) in 1984-85. Later on its share have started declining till 1993-94 when its share was 2.98% (6.32 Mtoe). This small share of primary electricity reflects the dominating role played by fossil fuels in Indian energy supply pattern.

The share of natural gas which was 2.08% (1.24 mtoe) in total primary energy had increased to 8.15% (15.42 Mtoe) in 1990-91 and then the supply remained stagnant at 15.98 Mtoe. This indicates the increase in the production of natural gas and utilisation of it instead of flarring up.

From the preceding discussion it may be concluded that India's primary energy supply were met by two main sources of fossil fuels, coal and oil. With internal change in their respective shares their combined share varied between 85-90% during 1970-71 to 1994-95.

1.1.2 Energy Consumption.

The analysis in this section covers the three principal forms of energy viz; coal, oil and electricity consumption, while the overall consumption of commercial energy increased nearly 2.5 times from 54 million tonnes of oil equivalent(Mtoe) to 130.6 Mtoe

over the period 1972-73 to 1991-92, the per capita consumption increased from 112 kgoe to 235 kgoe i.e. less than the increase in the consumption. This is very low as against the world average of over 1500 kgoe per capita and much lower when compared to the levels prevailing in the high income countries. The situation however, would be somewhat different if one takes into account traditional energy consumption.

For the analysis of sectoral energy consumption the whole economy may be divided into five subgroups; namely, (1)Household sector (domestic sector) (2)Agricultural sector (3)Industrial sectors (4)Transport (5)Other sectors. As regards the sectoral distribution of energy there has been significant change in the structure of the economy. Table 1.8 provides the sectoral break-up for the period ranging from 1970-71 to 1991-92.

It is evident from the Table 1.8 that while the share of industry in the total commercial energy consumption has increased in absolute term from 29.71 Mtoe in 1972-73 to 36.9 Mtoe in 1980-81 and further to 61.8 Mtoe in 1991-92, in percentage term the share has declined from 54.9% in 1972-73 to 51% in 1991-92. However, it may be noted that within the industrial sector the relatively larger decline in fuel consumption for energy purpose was partly offset by an increase in the demand for non-energy uses from 7% in 1972-73 to 9% in 1991-92. So despite a declining trend, the industrial sector continues to be the single largest consumers of commercial energy with its share at a little over 60%. The main reason behind this decline trend may be the structural change of the economy on the one hand and the reliance on the captive plants on the other. The share of transportation sector which is also a major consumer of energy particularly of oil, has experienced a similar declining trend. The share of this sector has declined from 25% in 1972-73 to 22.4% in 1991-92 due to modernisation of railways. As is shown in the table while the share of industry and transportation sector have declined, the energisation of irrigation pumpsets and the introduction of HYV crops has led to the rapid increase in the demand for electricity and petroleum products. As a result the share of agriculture increased from a mere 1.4% in 1972-73 to 4.1%

Table 1.8. Share of different sectors in the energy consumption

Unit's in Mtoe

Year	Agri culture	Industry	Tran- sport	H.Hold	Other Uses	Non-Energy	Total
1972-73	0.7	29.7	13.5	4.5	1.5	3.9	54.1
	(1.4)	(54.9)	(25.1)	(8.4)	(2.9)	(7.3)	(100)
1980-81	1.6	36.9	17.4	5.6	1.9	5.3	68.8
	(2.4)	(53.6)	(25.4)	(8.2)	(2.8)	(7.7)	(100)
1981-82	1.6	40.6	17.8	6.3	2.0	6.5	74.8
	(2.2)	(54.3)	(23.8)	(8.4)	(2.7)	(8.7)	(100)
1982-83	1.9	44.2	18.8	6.8	2.1	6.7	80.5
	(2.3)	(55.0)	(23.3)	(8.5)	(2.6)	(8.3)	(100)
1983-84	1.9	46.3	19.7	7.3	2.2	6.4	83.7
	(2.3)	(55.3)	(23.5)	(8.7)	(2.6)	(7.7)	(100)
1984-85	2.1	46.6	20.3	8.0	2.3	7.1	86.5
	(2.5)	(53.9)	(23.5)	(9.3)	(2.7)	(8.2)	(100)
1985-86	2.4	50.1	21.7	8.8	2.5	8.0	93.4
	(2.6)	(53.6)	(23.3)	(9.4)	(2.6)	(8.5)	(100)
1986-87	2.8	53.4	22.8	9.5	2.7	9.0	100.3
	(2.8)	(53.3)	(22.7)	(9.5)	(2.7)	(9.0)	(100)
1987-88	3.6	51.3	24.5 .	10.4	3.0	8.9	101.6
	(3.6)	(50.5)	(24.1)	(10.2)	(2.9)	(8.8)	(100)
1988-89	3.9	56.2	26.1	11.5	3.7	9.6	111.0
	(3.5)	(50.7)	(23.5)	(10.4)	(3.3)	(8.7)	(100)
1989-90	4.3	60.5	27.7	12.3	3.6	12.7	121.2
	(3.7)	(47.3)	(24.1)	(10.7)	(3.1)	(11.1)	(100)
1990-91	4.8	63.1	28.0	12.6	3.9	12.6	124.9
	(3.8)	(49.7)	(22.5)	(10.1)	(3.1)	(10.8)	(100)
1991-92	5.6	66.1	29.3	13.1	4.0	12.6	130.6
	(4.3)	(51.0)	(22.4)	(10.0)	(2.6)	(9.7)	(100)

Note: The figures in parenthesis indicate the percentage shares.
Source: India's Energy Sector, Centre for Monitoring Indian Economy, July 1995.

in 1991-92. And finally the share of household sector has also increased its share in total energy consumption from 8.4% to 10% during the same period.

Having being discussed the share of different sources of energy in the above classified sectors, let us discuss in depth the sector wise consumption of different forms of commercial energy. The relative share of different sectors in the consumption of coal, oil, and electricity have changed gradually over time. The following table gives the percentage share of consumption of coal in different sectors of the economy over the period of time covered in the analysis.

As is evident from the Table 1.9, coal is mainly consumed by the industrial sector and the traction sector, while the consumption of agriculture and the residential sector is very negligible or absolutely zero over the years. This low or zero level of consumption in residential sector may be attributed to the decrease in supply of the soft coke on the one hand and increase in the use of kerosene and LPG due to its efficiency on the other.

Table 1.9. Sectorwise Consumption of Coal During 1980-81 to 1991-92.

Unit's in Mtoe.

Year	Agri	Industry	Tract	Resed	Other	N.En	Total
1980-81	---	25.8(84.8)	4.6(15.2)	---	---	---	30.4(100)
1981-82	---	29.0(86.8)	4.4(13.2)	---	---	---	33.4(100)
1982-83	---	32.4(88.2)	4.3(11.8)	---	---	---	36.7(100)
1983-84	---	34.0(87.4)	4.2(10.8)	---	---	---	38.9(100)
1984-85	---	33.2(89.9)	3.7(10.1)	---	---	---	36.9(100)
1985-86	---	36.1(91.1)	3.8(8.9)	---	---	---	39.9(100)
1986-87	---	38.5(91.8)	3.2(7.2)	---	---	---	41.7(100)
1987-88	---	35.5(92.4)	3.0(7.6)	---	---	---	38.4(100)
1988-89	---	39.7(93.4)	2.8(6.6)	---	---	---	42.5(100)
1989-90	---	44.3(95.1)	2.3(4.9)	---	---	---	46.6(100)
1990-91	---	46.2(95.6)	2.1(4.4)	---	---	---	48.3(100)
1991-92	---	48.7(96.1)	2.0(3.9)	---	---	---	50.7(100)

* Use of coal for power generation is not included.

--- indicates the particular sector's demand as zero.

Note: The figures in parenthesis indicate the percentage shares.

Source: Tata Energy Data Directory and Yearbook, 1994-95.

As far as the share of industry is concerned, it has been steadily increasing over the years. While the share of industry was 84.86%(25.8 Mtoe) in 1980-81, it has increased to 96.05%(48.7 Mtoe) by 1991-92. In the industry group power utilities are the major consumer of coal in India. Those account for over 60% of the total coal offtake in the country. During the eighties coal offtake by power plants increased at the rate of 13% per annum. The next major consumer of coal in the industry group is the steel industry. They account for more than 10% of the total coal offtake followed by the cement industry which account for nearly 4% of the total coal offtake in a year.

While the share of industry is increasing over the years the transport sector has experienced a declining trend in its share of coal consumption. During 1980-81 the share of transport was 15.14%(4.6 Mtoe) of the total coal consumption which steadily declined to 3.95%(2 Mtoe) by 1991-92. This declining trend is experienced mainly due to electrification and diesel locomotion of the railways which was the major consumer in the transport sector.

Next comes the oil sector, the share of different sectors in the consumption of oil for selected years are given in the Table 1.10.

Petroleum products are consumed in almost all sectors of the economy either as fuel or as feedstock. In the domestic sector, LPG and Kerosene are major products used for cooking and lighting. In the transport sector, Motor spirit(MS), diesel and aviation turbine fuel(ATF) are used as fuel. In the industrial sector, the products used are naphtha/(NGL), high speed diesel(HSD), light diesel oil(LDO), furnace oil(FO), low sulpher heavy stock(LSHS), etc. In the agricultural sector, HSD is used as fuel for pumpsets, tractors, harvesters, etc. LDO, diesel, NGL/naphtha, FO/LSHS are used for power generation both as primary and secondary fuels.

Table 1.10. Sector wise Consumption of Petroleum Products during 1980-81 to 1991-92.

Unit's in Mtoe

Year	Agri	Industry	Tract	Resed	Other	N.En	Total
1980-81	0.4(1.4)	6.7(22.8)	12.6(43.0)	4.1(13.9)	0.7(2.4)	4.8(16.4)	29.
1981-82	0.3(1.0)	6.8(21.7)	13.2(42.1)	4.6(14.7)	0.8(2.5)	5.7(18 2)	31.
1982-83	0.3(0.9)	6.8(20.4)	14.2(42.7)	5.2(15.7)	0.9(2.7)	5.7(17.2)	33.
1983-84	0.3(0.9)	6.9(20.1)	15.2(44.3)	5.6(16.3)	1.0(2.9)	5.3(15.4)	34.
1984-85	0.3(0.8)	7.5(20.2)	16.4(44.2)	6.2(16.7)	1.0(2.7)	5.8(15.6)	37.
1985-86	0.4(1.0)	7.7(19.5)	17.7(44.9)	6.7(17.0)	1.1(2.8)	5.9(14.9)	39.
1986-87	0.4(0.9)	7.9(18.6)	19.3(45.5)	7.3(17.2)	1.2(2.8)	6.3(14.8)	42.
1987-88	0.4(0.9)	8.3(18.4)	21.2(47.0)	7.9(17.5)	1.3(2.9)	6.0(13.3)	45.
1988-89	0.3(0.6)	8.2(16.9)	23.0(47.6)	8.6(17.8)	1.7(3.5)	6.5(13.4)	48.
1989-90	0.5(0.9)	8.8(16.6)	25.1(47.2)	9.4(17.7)	1.9(3.6)	7.3(13.7)	53.
1990-91	0.6(1.1)	9.0(16.6)	25.6(47.3)	9.5(17.6)	2.0(3.7)	7.4(13.6)	54.
1991-92	0.6(1.1)	9.9(17.6)	26.9(48.0)	9.8(17.5)	1.4(2.5)	7.4(13.2)	56.

Note: The figures in parenthesis indicate the percentage shares.
Source: Tata Energy Data Directory and Yearbook, 1994-95.

Consumption of petroleum products increased at a rate of about 6% per annum during the eighties. This growth declined in the nineties as industrial activity slowed down during this period. The growth rate declined from 7% per annum during the second half of the eighties to less than 3% per annum during the period 1990-91 to 1993-94. The demand for petroleum products is estimated to increase by 7.6% per annum during the eighth plan period. According to the eighth plan, consumption would reach 79.3 million tonnes during 1996-97.

From the Table 1.10 one could observe that the transport (traction) sector has accounted for the largest share of oil consumption since 1980-81. Its share has increased steadily over time from 43.0%(12.6 Mtoe) in 1980-81 and it increased to 45.51%(19.3 Mtoe) during 1986-87 which further increased to 48.04%(26.9 Mtoe) in 1991-92. On the contrary, the share of industries has steadily declined. In 1980-81, the share of industries was 22.87%(6.7 Mtoe) which declined to 18.64%(7.9 Mtoe) in 1986-87 and further to 17.67%(9.9 Mtoe) during 1991-92.

As far as the domestic(residential) sector is concerned, the share of which is increasing steadily over time from 13.99%(4.1 Mtoe) in 1980-81 to 17.22%(7.3 Mtoe) in 1986-86 which further increased to 17.5%(9.8 Mtoe) in 1991-92. This steady increase may be attributed on the one hand to a decrease in the supply of soft coke and the increase in the use of more efficient petroleum products like kerosene and LPG gas etc on the other.

Further, the agricultural sector whose share in total consumption of petroleum products was very low during 1950's and 1960's had picked up in their share with the energisation of agriculture i.e., with the increase in the use of tractors and irrigation pumps in the 70's and 80's. Since then its share is fluctuating between 1 to 2% of the total consumption.

Table 1.11. Sector wise Consumption of N.Gas During 1980-81 to 1991-92.

Unit's in Mtoe

Year	Agri	Industry	Tract	Resed	Other	N.En	Total
1980-81	---	0.3(33.3)	---	---	---	0.5(55.5)	0.9
1981-82	---	0.4(30.7)	---	---	---	0.9(69.2)	1.3
1982-83	---	0.5(33.3)	---	---	---	1.0(66.6)	1.5
1983-84	0.1(5.8)	0.5(29.4)	---	---	---	1.1(64.7)	1.7
1984-85	0.1(4.7)	0.6(28.5)	---	0.0(neg)	---	1.3(61.9)	2.1
1985-86	0.1(3.5)	0.6(21.4)	---	0.0(neg)	---	2.1(75.0)	2.8
1986-87	0.1(2.6)	1.0(26.3)	---	0.0(neg)	---	2.8(73.7)	3.8
1987-88	0.1(2.5)	1.0(25.0)	---	0.0(neg)	---	2.9(72.5)	4.0
1988-89	0.1(2.2)	1.2(27.2)	---	0.0(neg)	---	3.1(70.4)	4.4
1989-90	0.1(1.6)	0.6(09.8)	---	0.0(neg)	---	5.4(88.5)	6.1
1990-91	0.1(1.6)	0.7(11.8)	---	0.0(neg)	---	5.1(86.4)	5.9
1991-92	0.1(1.6)	0.6(10.1)	---	0.1(1.7)	---	5.2(88.1)	5.9

Note: The figures in parenthesis indicate the percentage shares.

--- indicates that the particular sectors demand is zero.

Sources: Tata Energy Data Directory and Yearbook, 1994-95. and Various Issues of CMIE.

From the Table 1.11, one would observe that the share of non-energy use of natural gas has been steadily increasing over the years. During 1980-81 it was 55.56%(0.9 Mtoe) and this increased to 88.13%(5.2 Mtoe) in 1991-92. On the other hand the share of the industrial sector is decreasing from 33.34%(0.3 Mtoe) to 26.32%(1.0 Mtoe) in 1986-87 which further decreased to 10.16%(0.6 Mtoe) in 1991-92. However, the use of natural gas in the agricultural sector where it is basically in the tea plantation remains stagnant throughout the period under study, the quantity consumed being 0.1 Mtoe.

The Table 1.12 sets out the relative share of different sectors in electricity consumption.

Table 1.12. Sectorwise Consumption of Electricity during 1980-81 to 1991-92. Unit's in Mtoe.

Year	Agri	Industry	Tract	Resed	Other	N.En	Total
1980-81	1.2(17.1)	4.1(58.5)	0.2(2.8)	0.8(11.4)	0.7(10.0)	---	7.0
1981-82	1.3(17.1)	4.5(59.2)	0.2(2.6)	0.9(11.8)	0.8(10.5)	---	7.6
1982-83	1.5(18.5)	4.5(55.5)	0.2(2.4)	1.0(12.3)	0.9(11.1)	---	8.1
1983-84	1.5(17.4)	4.8(55.8)	0.2(2.3)	1.1(12.7)	0.9(10.4)	---	8.6
1984-85	1.8(18.7)	5.3(55.2)	0.2(2.1)	1.3(13.5)	1.0(10.4)	---	9.6
1985-86	2.0(19.2)	5.7(54.8)	0.3(2.8)	1.5(14.4)	1.0(9.6)	---	10.4
1986-87	2.4(20.8)	6.0(52.1)	0.3(2.6)	1.6(13.9)	1.2(10.4)	---	11.5
1987-88	3.2(23.7)	6.5(48.1)	0.3(2.2)	2.0(14.8)	1.4(10.3)	---	13.5
1988-89	3.5(23.9)	7.1(48.6)	0.4(2.7)	2.1(14.4)	1.5(10.2)	---	14.6
1989-90	3.7(25.0)	6.8(45.9)	0.3(2.0)	2.5(16.9)	1.4(09.4)	0.0(neg)	14.8
1990-91	4.2(26.2)	7.2(45.0)	0.4(2.5)	2.6(16.2)	1.7(10.6)	0.0(neg)	16.0
1991-92	4.9(28.0)	7.4(42.2)	0.4(2.8)	3.0(17.1)	1.8(10.3)	0.0(neg)	17.5

Note: The figures in parenthesis indicate the percentage shares.
--- indicates that the particular sector's demand is zero.

Sources: Tata Energy Data Directory and Yearbook , 1994-95. and Various Issues of Centre for Monitoring Indian Economy.

As is evident from the Table 1.12, agriculture sector has increased its-share in the total electricity consumed. In fact it

has been the fastest growing power consuming sector. Power consumption in agriculture expanded at the rate of 12-13% per annum during the period 1970-71 to 1991-92. As a result, this sector's share in the total power consumed has increased steadily from 10% in 1970-71 to 17.14%(1.2 Mtoe) in 1980-82 which further increased to 28%(4.9 Mtoe) in 1991-92. Power consumption in agriculture has increased because of an increase in irrigation pumpsets energised and a sharp increase in the uses hours of the pumpsets. Another reason which may be responsible for a rise in power consumption in this sector is the high level of subsidy provided to agriculture which has permitted, if not encouraged, the inefficient use of pumpsets. For instance, electricity consumed in the agriculture sector per pumpset installed has increased from an average of 3672 KWH in 1984-85 to 6880 KWH in 1993-94.

Electricity consumption in the industrial sector has grown at a relatively slower pace. During the seventies it grew at a rate of 5% per annum. This growth rate increased somewhat to 5.8% in the eighties and then declined to 4% in the early nineties. Though in absolute term the consumption in electricity in this sector has increased from 4.1 Mtoe in 1980-81 to 7.4 Mtoe in 1991-92, the share of power consumption in the industrial sector from the utilities has been on continuous decline. The share of the industrial sector declined from about 58% in 1980-81 to only about 40% in 1993-94. Part of this decline is due to the increasing reliance of the industrial sector upon captive power plants. Nearly 43% of the total electricity consumed in major power consuming industries was from the captive power plants during 1989-90 and this ratio has been rising steadily over the years. Another factor to which the fall in electricity consumption may be attributed is the higher efficiency in selected industries and structural shift in industrial sector. For instance several of the relatively newer and fast growing industries such as gems and jewellery, garments and electronics are far less energy intensive than the traditional heavy industries such as steel, aluminium, and cotton textile, while in some other industries like paper, newsprint, cotton and blanded yarn, aluminium, fertilizer, automobile, cement the intensity has reduced.

The share of household(residential) sector has been steadily increasing over the period under study, as shown in the Table 1.12. This is clear from the fact that the share of household sector during 1980-81 was 0.8 Mtoe(11.42%) which had increased to 1.3 Mtoe(13.54%) during 1984-85, which further increased to 3.0 Mtoe(17.14%) during 1991-92.

1.2. Purpose of the Study.

The energy sector has been the centre of much debate on development planning in the recent years. Nearly 30% of the total plan outlay is earmarked for the energy sector every year and still traditional and inefficient sources of energy account for nearly 40% of the total energy consumed in the country. Nearly 40% of the total proposal for investments, which includes private, government and foreign investments, are outstanding in the energy sector. And yet, if there is any sector which seems to be starved of sufficient investment, it is the energy sector. The description of energy sector of the Indian economy made above gives us an idea about the use of commercial energy, their growth and distribution that has taken place in the economy since 1970's but at a very broad and aggregated level such as domestic, industry, commercial, transport etc. There have been, however, very few studies and descriptions of the energy sector of the Indian economy during this period which have analysed the growth and distribution at a disaggregated level. The understanding of the structural need and change of an economy in detail is very much essential for its planned development. There is an inherent need for examining the detailed structural need of an economy and its relationship with the growth of the economy in order to find out whether the two are going hand in hand i.e whether the supply and demand of energy perfectly match each other. The purpose of this study is to analyse the need and change of energy requirement of the Indian economy with the help of Input-Output tables. To that effect we have used the I-O tables of India for the years 1979-80, 1984-85, 1989-90 and 1991-92, prepared by the Planning Commission, Government of

India. The selection of the period of 13 years ranging from 1979-80 to 1991-92 for the purpose of the study has been due to the availability of data for the period. These tables provide information regarding the production activities of the economy in greater detail and can be used for the analysis of energy studies.

The present study has been designed in such a way that its findings could be useful in development planning for the Indian economy. First, it integrates the energy data with an input-output account and provides a unified framework for describing the relationship between energy and other factor inputs; consequently this gives a framework for the relationship between energy and the economy. Secondly, determining the extent and direction of impacts on aggregate energy intensity of structural, technological and other factors. This analysis conveys to the policy makers about the energy consequences of past decisions and provides a basis for future policy. The present study by comparing the energy input-output tables constructed for different years, attempts to analyse the nature and implication of changes in the structure of production, in technology and in cost for the Indian economy over the period 1979-80 to 1991-92 as comprehensively as possible. Further it also attempts to study the sources of intensity change which can help to improve the quality of energy demand forecasting.

1.3. Choice of Methodology.

This study relies heavily upon the analytical framework provided by the Input-Output technique.

The input-output technique is not unique in providing a framework for analysing the energy sector of Indian economy. Numerous other economic models including growth models and econometric models have been used for this purpose. However, each of these models differ in terms of the theories upon which they are constructed and the types of issues which they are designed to

investigate. Here our aim is not to compare the alternative models that are used to tackle the energy problem, but to stress on the use of I-O technique to study the energy problem of the Indian economy. However, it should be stressed that the I-O model is better suited for analysing the changes of energy use and intensity in different sectors and the underlying production process on several counts. Firstly, I-O tables give a much greater level sectorisation detail than is available in most other analytical studies. Secondly, the I-O model encompasses all productive activities and from this perspective can be viewed as being complete model of industrial production. Finally, in I-O model government policies, economic behaviors of producers and consumers and foreign trade variables are determined by factors outside the model. This enables attention to be concentrated on the technology of production and the inter relationship among industries in production activities. Hence, owing to the nature of the problem of the present study and the availability of data, the I-O approach has been adopted as a methodological choice for analysing the energy intensity of the different sectors and the change in energy use in the Indian economy over the period 1979-80 to 1991-92.

The exercises described in the following chapters are primarily concerned with the calculation of energy intensity of different sectors, assessing the cost share of energy in the production of different sectors, the changes in energy use over different periods and then the decomposition of the energy use change into technological changes and final demand changes over the period 1979-80 to 1991-92.

1.4. Arrangement of Chapters.

This study consists of seven chapters. Chapter 2 and 3 provide a review of the background literature for the study, explain the specific objective of the study and present a description of the basic data used in subsequent analysis. In particular, chapter 2 describes the I-O model, gives a summary of other studies of energy intensities, and structural change in an

I-O framework, describes the specific objectives of the study and explains the steps that have been taken up to meet these objectives.

Chapter 3 discusses the principal characteristics of the I-O tables and supplementary energy and employment data collected from different sources which provide the basic data for the purpose of this study and explains the adjustments made to this data to improve their inter-temporal comparability.

Chapters 4 to 6 provide detailed empirical analysis of the extent of the energy intensity and structural change in energy use in Indian economy during the period 1979-80 to 1991-92. The analysis presented in chapter 4 is concerned with the energy intensity in different sectors of the economy and the changes in intensity over the same period of the different sectors.

Chapter 5 is devoted to study the changes in total energy use of the economy within the sub-periods of 1979-80 to 1984-85, 1984-85 to 1989-90 and 1989-90 to 1991-92 and the whole period of 1979-80 to 1991-92 thus giving an insight to both the short run and long run changes. Here in this chapter an attempt has also been made to study the sources of energy use change over the same period.

In chapter 6 an analysis of share of energy in production cost and its impact on the prices of the output of different Indian industries over the period under study is presented. The sources of change such as the technological change and the value added change has been explained for the periods under study.

While a brief summary of the empirical analysis, major findings and the limitations of the study are presented in chapter 7. Further possible extension and suggestion has also been made in this chapter.

CHAPTER 2

THE INPUT-OUTPUT APPROACH, REVIEW OF LITERATURE AND THE OBJECTIVES OF THE STUDY

The purpose of this chapter is to describe the background, literature, and to present the input-output approach of economic analysis. In the first section, the basic input-output technique has been explained in detail and simple form. The second section is devoted to the review of literature of energy analysis carried out in the I-O framework in India and across countries, while the specific objectives of the study and the emphasis laid in this exercise have been described in the third and final section of this chapter.

2.1. The Input-Output Approach.

New economic ideas based on the general equilibrium analysis and macro economic framework were developed after the great depression of 1930's to understand the complicated relationship of an economy. But these models were too complicated to be used in empirical studies and remained unused until Prof. Leontief invented the tool of Input-output analysis. Though the credit for development and application of input-output analysis goes to Prof. Leontief, the method owes its origin to the French economist Francois Quesney, who in his "Tableaue Economique" had developed a diagrammatic representation of how expenditure can be traced through an economy in a systematic way. Over the years Input-output analysis has acquired much significance in the planning framework of the various economies.

Leontief's Input-output technique ,which is otherwise known as Inter industry technique, deals with the quantitative analysis of the inter dependence among various producing sectors of an economy as well as final consuming sectors. The basic information from

which an Input-output model is developed is contained in the inter-industry transaction table, which is a table of I-O transaction for various sectors (square matrix of order n, n being the number of sectors in the economy). The next section presents the basic features of the transaction table along with the fundamental relationships that exists.

2.1.1 Input-Output Tables & Fundamental Relationship.

The Input-output table of an economy shows the flow of goods and services from each industrial sector considered as producers to each of the sectors considered as consumers over a specified period of time, say, one year. It provides the system of interdependence of various sectors of the economy in the form of a two-way table. The rows of such a table describe the distribution of producers output throughout the economy which includes not only the producing sectors but also the final users. The columns describe the composition of inputs, which includes not only the inputs required from the producing sectors (associated with various rows) but also primary inputs such as; land, labour, capital etc. supplied by the value added sector of the economy, required by a particular industry to produce its output. The inter-industry exchanges of goods and services constitute the transaction table of the Input-output model. Besides the transaction table the additional column placed outside the transaction table, which records the sales of each sectors to final demand for their production/consumption such as personal consumption purchase, sales to the government and export is called the final demand vector. The additional row at the bottom of the transaction matrix which accounts for the other non-industrial inputs to production such as labour etc. is labeled as value added. A representative Input-output table is shown in the following figure 2.1. It should be kept in mind that although the Input-Output Tables was first prescribed in physical quantities, but due to practical difficulties associated with the units of measurement, now-a-days I-O tables are prepared by most of the countries in value-terms.

Figure 2.1 The Make-up of a Typical Input-Output table.

OUTPUT

	INTERMEDIATE USE COL			FINAL DEMAND COLUMNS	FINAL DEMAND	OUTPUT
	PRODUCTION SECTORS			AUTONOMOUS SECTORS		
	1 ,2, M, M+1, ,N			PRI GOVT INV EXP IMP N+1,N+2, N+3,N+4,N+5		
PRODUCTION	OUTPUT PRODUCED FOR INTERMEDIATE USE.		+	OUTPUT PRODUCED FOR FINAL USE.	=	TOTAL OUTPUT
SECTORS 1 2 N	INPUTS USED	INTERINDUSTRY TRANSACTION QUADRANT(I) (XIJ)		FINAL DEMAND(II) (FIK)	F1 F2 . . . FN	X1 X2 . . . XN
TOTAL	+	INTERMEDIATE USE.				
TAXES WAGES PROFIT RENT ETC.	PRIMARY INPUT USE	VALUE ADDED QUADRANT(III) (VJ)		DIRECT FACTOR PURCHASE - QUADRANT(IV)		
VALUE ADDED						
TOTAL	TOT USE					GROSS OUTPUT

TOTAL OUTPUT OF SECTOR I = TOTAL INPUT OF SECTOR I.
WHERE I = 1,2,.....,N.

In the figure 2.1, we have a representative of the structural make-up of a typical Input-output table. Most of the important information contained in the table is located within the three main quadrants; the inter industry transaction quadrant(I),the final use quadrant(II), the value added(III). The Direct factor purchase quadrant(IV) is important only for the accounting purpose especially for measuring the gross domestic product.

In Input-output model a particular sector, say, i is not only considered as a producing sector but also a consuming sector. The transaction quadrant is thus always a square matrix with the same number of rows as column ,one for each sector of the economy. Reading from left to right along any row,we see that part of the total output of that sector is sold to the other sectors for intermediate use in the production of their own output. Reading down any column in the transaction quadrant shows that a particular sector uses the output of other sectors as material inputs for its own production. In short, rows designate outputs, column represents inputs and each sector is both a user of inputs and producer of output. These transactions are represented in the figure as the delivery of the output of sector i to sector j. Hence the entries are lebelled as Xij which denotes the delivery of output from sector i to sector j. The total supply of output from sector i to all the producing sectors as inputs for intermediate use is denoted by Uj in the column of the total intermediate use. The total intermediate use as inputs by the sector j from all the producing sectors is denoted by Tj in the row vector of total intermediate inputs.

Turning to the final use quadrant,we see that the outputs of each sector are also normally demanded for ultimate use in the form in which they are produced. They may be purchased as consumption goods by individual consumers or government,as investments or they may be exported. In the figure, the sectoral deliveries to the final demand are shown as the output of the sector i delivered to the kth category of the final demand, denoted as fik.

In the production process, a particular sector uses as inputs not only the products of the other producing sectors but also those inputs which cannot be produced by the producing sectors and as such not described in this system e.g land,labour,capital. Such inputs are known as primary inputs. Reading down columns in the value added quadrants obtain information about the amounts of primary inputs used by each sectors in the production of its output. The sum of the value of these primary inputs used in the whole economy yields the total value added by the industries. Therefore labour(in the form of wages,salaries,other benefits etc.), land and buildings(in the form of rents), capital(in the form of depreciations, hire charges) or indirect taxes for government services like defence, law and order, international relations etc) are regarded as primary inputs or value added. For any particular sector the elements in each quadrants when added to the elements in the corresponding column of the transaction quadrant yield a value for total inputs purchased or used up. The payments for the primary inputs are represented in Fig 2.1 as V_j, where j refers to the j th producing sector.

Finally,the direct factor purchase quadrant shows those primary inputs which are employed by the final users. The transactions are represented as V_k . The inclusion of these transactions is necessary in order of the total of an Input-output table to be consistent with the national income and product aggregates.

The total production of sector i, denoted as X_i, is defined as the sum of the output of sector i to all producing sectors and final users.

That is

$$X_i = \sum_{j=1}^{n} X_{ij} + \sum F_{ik} \qquad i = 1, 2, \ldots, n \qquad \ldots\ldots\ldots\ldots (2.1)$$

where F_{ik} is the supply of output from the sector i to the k^{th} final demand category.Similarly the total input requirement of sector j denoted by X_j' is defined as

$$X_j' = \sum_{i=1}^{n} X_{ij} + V_j \qquad \ldots\ldots\ldots\ldots\ldots\ldots (2.2)$$

Equation (2.1) shows that the total domestic production of any sector is equal to the sector's product used by all the sectors in the economy as an input to produce their output plus the amount demanded for final use by consumers, net exports, investments, and government consumption. On the other hand, equation (2.2) indicates that the total domestic production of any sector is also equal to the total purchase made by the sector from all sectors in the economy plus all returns to the primary factors or value added in this sector.

As the total value of production of all the producing sectors is equal to the total cost of production in each sector in the I-O table, the sum over the rows is equal to the sum over the columns, for any given industry.

Thus,

$$\sum_{j=1}^{n} X_{ij} + \sum_{k=1}^{m} F_{ik} = \sum_{i=1}^{n} X_{ij} + V_j \qquad \ldots\ldots\ldots\ldots\ldots\ldots (2.3)$$

$$(i=1,2,\ldots\ldots\ldots,n,\; j=1,2,\ldots\ldots\ldots\ldots,n)$$

Further, the sum of all intermediate use and the sum of all final use should be equal to the sum of all intermediate inputs and the sum of total value added for all the sectors taken together. Therefore

$$\sum_{i,j=1}^{n}\sum^{n} X_{ij} + \sum_{i,k=1}^{n}\sum^{m} F_{ik} = \sum_{j,i=1}^{n}\sum^{n} X_{ij} + \sum_{j=1}^{n} V_j \qquad \ldots\ldots (2.4)$$

$$(i=1,2,\ldots\ldots,n,\; j=1,2,\ldots\ldots n,\; k=1,2,\ldots\ldots\ldots,m)$$

From the equation (2.4) above, it is derived that the sum

of value added is equal to the sum of all supply to the final demands. Or

$$\sum_{j=1}^{n} Vj = \sum_{i=1}^{n}\sum_{k=1}^{m} Fik \quad \ldots\ldots\ldots\ldots (2.5)$$

The above equation (2.5) is one of the important identities of Input-Output model.

2.1.2. The Vital Assumptions Of I-O Analysis.

The Input-Output table is used in analysing and projecting the performance of an economy. For adopting the I-O for such use, it has to be converted from a descriptive device into an analytical model. For this several assumptions have been made which are as follows.

The crucial assumption of Input-output analysis i.e the one that makes the system operationally effective are concerned entirely with the nature of production. Input-output theory assumes that each sector produces with the common single input structure. In other words the Input-output assumes that each sector produces a single homogenous product with common input structure and there is no substitution between the input of different sectors. This assumption allows each commodity to be associated with a particular industry. Hence the basic unit of an I-O model is the industry which represents many firms producing homogenous products and employing an unique and fixed technique of production.

The second important assumption made is that the quantity of each input used in production by any sector is determined entirely by the level of output of that sector or in other words, there is a fixed proportion of the Leontief production function. The assumption of fixed input requirements states that to produce one unit of output of the jth commodity, the input used of the ith

commodity must be a fixed amount say aij = Xij/Xj. If Xj represents the total output of the jth commodity, the input requirement of the ith commodity will be aij or Xij = aij Xj. The symbol aij is referred to as an input coefficient or technical coefficient. This assumption implies that all production process exhibit constant returns to scale and there is no substitution among inputs in a given production process.

The third assumption states that the Hawkins-Simons(1949) condition must be satisfied by the Input-output table. This condition ensures that the level of gross output in each sector is adequate to meet the intermediate and final demands for the sectors or alternatively the output Xi should not be less than the direct and indirect requirements of the output of this sector.

Although these assumptions are very rigid it should not be stressed that the overall usefulness of the Input-output model is not determined by the validity of its assumption but rather by the accuracy with which it can predict certain economic events (Friedman,1953)

2.1.3. The Basic I-O Model.

The Input-output model is a linear, intersectoral model of output determination. It can show how production level in one sector generate successive rounds of demand for the products of other sectors. The emphasis of this model is placed on the linkages between the sales and purchase of this inputs. Because of its general equilibrium character, the Input-output model has been recognized as a useful method for analyzing and forecasting overall economic impacts.

From the transaction or inter-industry matrix, the technical coefficient matrix can be derived. The technical coefficients describe the amount of each input required in the production of a given unit of output. These coefficients are derived as

$$a_{ij} = X_{ij}/X_j \quad \ldots\ldots\ldots\ldots (2.6)$$

The technical coefficients are arranged in a matrix, following the same format as the transaction matrix in the Input-Output tables. This matrix is called the technical coefficient matrix and is denoted as A, where

$$A = \begin{bmatrix} a_{11} & a_{12} & \ldots & a_{1n} \\ a_{21} & a_{22} & \ldots & a_{2n} \\ \ldots & \ldots & \ldots & \ldots \\ a_{n1} & a_{n2} & \ldots & a_{nn} \end{bmatrix}$$

The matrix is called the technical coefficient matrix because in such a matrix, the technology of production is clearly displayed.

The Input-Output model is essentially a production model based on inter-sectoral relationships determined by technological requirements. In this model, technical coefficients are assumed to be fixed (for a time period) and final demands are exogenous to the model. The quantity and price are two distinct entities and can be analysed independently of each other.

As defined in equation 2.1, the following equations can be expressed-

$$\begin{aligned} X_1 &= X_{11} + X_{12} + \ldots\ldots\ldots\ldots + X_{1n} + F_1 \\ X_2 &= X_{21} + X_{22} + \ldots\ldots\ldots\ldots + X_{2n} + F_2 \\ X_3 &= X_{31} + X_{32} + \ldots\ldots\ldots\ldots + X_{3n} + F_3 \\ &\vdots \\ X_n &= X_{n1} + X_{n2} + \ldots\ldots\ldots\ldots + X_{nn} + F_n \end{aligned}$$

$$\ldots\ldots\ldots\ldots\ldots\ldots (2.7)$$

From equations (2.5) if we substitute $a_{ij} X_j$ in place of X_{ij}, we can express (2.7) as:-

$$Xi = \sum_{j=1}^{n} aij \quad Xj + Fi \quad \ldots\ldots\ldots\ldots(2.8)$$
$$i = 1,2,\ldots\ldots\ldots\ldots,n$$

The system of equation can be written in an abbreviated matrix form as

$$X = AX + F \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2.9)$$

where X = n x 1 vector of gross output,

A = n x n matrix of technical coefficients,

F = n x 1 vector of final demand

or

$$X - AX = F$$
$$X(I-A) = F$$
$$X = (I-A)^{-1}F \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2.10)$$
$$= BF \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2.11)$$

Where A is the direct input coefficient matrix , I is the identity matrix , and B is the Leontief inverse matrix. The above equation describes the relationship between the final demand and total production in the input-output model. It is used to determine the levels of gross output which are required to meet the demands for a given bill of final goods and also support all the producing activities involved in providing these final goods. The elements of the inverse matrix,B, represents the total inter dependence coefficient, which indicates the total direct and indirect requirements by sectors per unit of output to final demand.

With the help of (2.11), we can also calculate the primary input requirements of production activities. For example, let us take labour. If information on sectoral employment is available, the direct labour-output coefficient can be defined as-

$$li = Li / Xi \quad , i=1,2,\ldots\ldots\ldots, n \quad \ldots\ldots (2.12)$$

where, Li = labour employed in sector i (in numbers);

Xi = gross output of the sector i (in value) ; and

li = direct labour output coefficient i.e. input of labour per unit of output in sector i.

As in the case of technical coefficients, the primary input coefficients are also assumed to be fixed in the short run due to no substitution among the primary inputs. The labour requirement can thus be estimated as

$$L = l'(I - A)^{-1} * F \quad \ldots\ldots\ldots \quad (2.13)$$

where L = $1 * n$ matrix of total labour requirements associated with the production of final demand F;
and l' = $1 * n$ vector of direct labour output coefficients.

2.1.4 Price Model in Input-Output Framewok.

The analysis of cost price relationship in the Input-output model is based on the assumption of average cost pricing. According to this assumption the cost of each product or output is determined as a weighted average of all input prices. If the Input-output table is given in physical units and not in values, then the accounting identity between the receipts and costs in the jth industry is represented as

$$Pj\ Xj = P1\ X1j + P2\ X2j + \ldots\ldots + Pn\ Xnj + Pvj\ Vj \quad \ldots(2.14)$$

where Pj = Price of output of the j^{th} sector
Pvj = Price associated with value added in the j^{th} sector,
and Vj = Value added in the j^{th} sector.

Dividing both sides of the above expression by Xj we have

$$Pj = P1\ a1j + P2\ a2j + \ldots\ldots + Pn\ anj + Pvj\ vj \quad \ldots\ldots(2.15)$$

where $v = Vj/Xj$ the value added generated per unit output in the jth sector.

The first n terms on the right hand equation (2.14) indicates the cost of intermediate inputs required in the production of one unit of output of the sector j . The term Pvj vj indicate the value added or the returns to primary inputs per unit of output of sector j . Expression (2.15) can be written in matrix notation as :

$$P - A'p = V$$

$$\text{or } (I-A')P = V$$

$$P = (I-A')^{-1} V \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.16)$$

where P = n x 1 vector of prices of output sectors
V = n x 1 vector of value added per unit of sectoral output
A' = transpose of the technical coefficient matrix

The P vector can also be computed as

$$P = V'(I-A)^{-1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.17)$$

Expression (2.16) or (2.17) shows that changes in output prices can result from changes in matrix of technical coefficients A or changes in the detailed composition of value added matrix.

Equation (2.17) shows that the changes in prices of output can be estimated with the help of data on changes in detailed composition of value added matrix v (if technical coefficient matrix is assumed to be stable).

In the above equations, it has been described how standard Input-Output technique can be used to estimate the change in output levels, sectoral price levels, sectoral primary input levels based on changes in demand or changes in prices of value added. Similar estimates can be made for change in specific category of final demand and value added, price of specific primary input. However, the above applications are strictly from the perspective of demand driven production cycle. It is called traditional Leontief model. This model does not explain things from the supply angle. This model is not in a position to

explain the effects on the economy if there is a change in one or more sectors supplying inputs. For this I-O model developed by A.Ghosh(1958) needs to be used,which helps in tracing the effects from the supply side changes. This model is briefly described below.

2.1.5 Input-Output Supply Driven Model.

The n sector Input-Output equations can be written by summing down the columns as below:-

$$X' = i' Z + V' \quad \ldots\ldots\ldots\ldots (2.18)$$

here (') denotes transpose matrix and

X' = a row vector of gross outputs;

Z = the inter-industry transaction matrix ;

V' = row vector with value added in different sectors;

i' = row vector of identity.

In this formulation, the interrelationships are fixed in such a way that supply of output of a sector is distributed in fixed proportion to other sectors. It is assumed so for each sector. From this we get the output coefficient (analogous to input-coefficient in demand model), matrix $A^{\sim}$ as below:-

$$\tilde{a}_{ij} = Z_{ij} \quad \ldots\ldots\ldots\ldots (2.19)$$

where

$$Z_i = \sum_{j=1}^{n} Z_{ij}$$

$$A^{\sim} = (\hat{X})^{-1} Z \quad \ldots\ldots\ldots\ldots (2.20)$$

here $A^{\sim}$ is derived by dividing the elements of each row of the Z matrix by the total output of that row vector. Thus we get:

$$X' = X' A^{\sim} + V' \quad \ldots\ldots\ldots\ldots (2.21)$$

which gives the supply side Input-Output solution (Output Approach) as:-

$$X' = V' (I - A^{\sim})^{-1} \quad \ldots\ldots\ldots (2.22)$$

If we denote the elements of the matrix $(I - A^{\sim})^{-1}$ by $R^{\sim}_{,}$ then equation (2.22) can be expressed as :

$$X' = V' R^{\sim} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2.23)$$

From this formulation, we can see that the relationship between output of a sector can be linked with value added in that sector, because $A^{\sim}$matrix is assumed to be fixed in short time period. Therefore the stimulus in the output due to unit increase in value added in a sector can be found out with the help of Supply-Model. The total increase in output for the whole system is given by

$$\sum_{j=1}^{n} R^{\sim}_{ij} \text{ , the row sum of the } (I - A^{\sim})^{-1} \text{ matrix .}$$

The $(I- A^{\sim})^{-1}$ matrix may be referred to as the Ghosh inverse or the output inverse matrix.

2.2. Studies of Energy Sector in I-O Framework: Review of Literature.

The development of the I-O approach as a technique for studying economic interdependence began with the work of Wassily Leontief in the 1930's (Leontief,1936 & 1960). As interest of I-O spread, also encouraged by the advent of softwares, more and more countries became involved in constructing Input-Output tables and employing Input-Output techniques in empirical analysis. Inter country and inter temporal comparison of input-output tables have been attempted in recent years and techniques of analysis developed, to explore structural change with view to establishing a meaningful relationship between the overall degree of industrialisation and its pattern.

In recent years much attention has been focused on extending the Leontief Input-output framework to account for factors associated with inter-industry activity such as energy consumption or environmental pollution. Ayres and Kneese (1969), Bullard and Herendeen (1974), Griffen (1976), Cumberland (1966) and many others reported these extensions. In the following section we discuss the energy Input-output model which is a simple extension of the Leontief input-output model.

The basic inter industry transaction as represented by the input-output table are expressed in monetary units. However, monetary units flow of energy may not be a good representation of energy use by the industry due to the fact that different sectors pay different prices for the same energy type. Hence energy flows expressed in physical units is more reliable than the value terms. A diagram of the Input-output table of energy flows will provide an idea of the attempted model. The Input-output table of energy flows are not at all tables which show energy flows only. They are rather, complete Input-output tables comprising all production activities. A diagram of Input-Output flows of energy streams is shown in the figure 2.3.

Energy intensity represents a set of measureable coefficients of the direct and indirect energy required for the formation of a unit of produced goods and services. These coefficients are of fundamental importance in energy analysis. Various measures for the energy intensity of produced goods have been suggested of which the I-O technique has gained considerable attention as the I-O technique in contrast to the conventional energy analysis. The I-O technique can efficiously provide a panorama of both direct and indirect energy flows throughout the entire economic system.

The traditional Leontief model contains three fundamental matrices: (1) a matrix of inter-industry transaction(Z), which traces inter industry flow in value terms from producing to consuming sectors. (2) A matrix of technical coefficient or direct

Figure 2.2 Diagram of the Input-Output table of Energy Streams.

OUTPUT

		INTERMEDIATE INPUTS	FINAL DEMAND	OUTPUT
		PRODUCTION SECTORS	AUTONOMOUS SECTORS	
		ENERGY NON-ENERGY 1,2,..M, M+1,....,N	PRI GOVT INV EXP IMP N+1,N+2, N+3,N+4,N+5	
PRODUCTION	SECTORS 1 2 M M+1 M+N	.... E_{mj} .... INTERMEDIATE DEMAND X_{ij}	.... E_{mk} .... FINAL DEMAND F_{ik}	.... E_t .... X_t
TOTAL INTERMEDIATE INPUTS				
INDIRECT TAXES WAGES & SALARY PROFIT INTEREST		GROSS VALUE ADDED		
TOTAL INPUTS				

SHADED AREAS, FLOWS IN TERMS OF PHYSICAL UNITS.

requirement matrix A, which reflect the input required to produce one unit of output in value terms of goods and services (3) a matrix of total requirements (the Leontief inverse) which yields the output again in value terms of each industry required to support a unit of final demand for an industry's output and hence the final solution is given by the equation

$$X = (I-A)^{-1}F$$

In energy Input-Output we seek analogous set of matrices to Z, A, and $(I-A)^{-1}$ i.e. an energy transaction or flow matrix, a direct energy requirement matrix, and finally a total energy requirement matrix. Here the unit of measurement is, however, in physical units, in contrast to the value terms in the Leontief approach because the value data are inferior to physical, being more subject to economies of scale. Secondly, reliance on monetary data for all users which is very much questionable in the present world.

Perhaps the most straight forward approach, and indeed the first one adopted by Strout(1967), Wright(1974),and Bulard and Herendeen(1975) is to construct a matrix of energy flows in physical units. They assumed uniform energy tariffs for all economic sectors as means of converting value terms to physical terms. That is, given a n sector input-output economy, let us assume that m of the n sectors are energy sectors. Hence the matrix of energy flows E would be of dimension mxn, if we also assume that energy consumed by the final demand is given by E_y and the total consumption in the economy by E_t (E_y& E_t are of the order mx1), the energy flows accounting matrix analogous to the Leontief system is given by

$$E_i + E_y = E_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2.24)$$

i.e the sum of energy (of each type depicted by the rows of E) consumed by inter industry(E_i) plus that consumed by the final demand(E_y) is equal to the total demand of energy(E_t) consumed in the economy.

Let us define a set of direct energy coefficient, $D = [d_{kj}]$, i.e the amount of energy type $k = 1,2.....m$ required to produce one rupee worth of each producing sector output $j = 1,2.....n$ as

$$D = E(\hat{X})^{-1} \quad \text{.................................(2.25)}$$
$$\Rightarrow \quad E = D\hat{X}$$

combining and rearranging equations (2.24) and (2.25) we can obtain, the inter industry demand as

$$E_i = D\hat{X}i = DX = D(I-A)^{-1}Y \quad \text{...........(2.26)}$$

then to calculate the direct energy consumption, E_y, we need to make adjustment in final demand as

$$E_y = S\,Y \quad \text{..............................(2.27)}$$

$$\text{where } S_{kj} = \left[\begin{array}{ll} e_{ky}/Y_k & k=j \\ 0 & \text{otherwise} \end{array}\right.$$

The total energy consumption E_t is now obtained as

$$E_t = D(I-A)^{-1}Y + SY = [D(I-A)^{-1} + S]Y \quad \text{......(2.28)}$$

where the term $[D(I-A)^{-1} + S]$ gives the direct and indirect energy required to produce one rupee worth of output.

Later Bulard and Herendeen(1975) showed that, in particular, there are substantial difference in price paid for energy by sectors of the economy and, since the product of one sector usually becomes the input of another, the assumption of single overall tariff for all of the energy of a given form used directly and indirectly by a single industry can cause substantial errors. If actual physical energy transaction data can be used wherever possible, instead of the conversion of value data using tariff, then the accuracy is further improved. The method of Bulard and Herendeen as developed is regarded as the most generally useful

for energy analysis because it allows for the distinction between primary and secondary energies, which is not possible with other methods and secondly it satisfies the law of conservation of energy(Miller and Blair 1985).

Adopting the new theory, we now define a new transaction matrix Z* by inserting the energy flow matrix E directly into the transaction matrix Z, such that the cell entries of energy sectors are in physical units and that of the non-energy sectors are in value terms. The corresponding total gross output X* and the final demand vector F* are defined in the similar way. The corresponding matrices A* and (I-A*) inverse can be derived in the usual method. It should be remembered that the Hybrid unit's direct requirement matrix A* is of the form

$$A^* = \begin{bmatrix} \text{Mtoe/Mtoe} & \text{Mtoe/Rs} & \text{Mtoe/Rs} \\ \text{Rs/Mtoe} & \text{Rs/Rs} & \text{Rs/Rs} \\ \text{Rs/Mtoe} & \text{Rs/Rs} & \text{Rs/Rs} \end{bmatrix}$$

In this matrix, the first sector is an energy sector and the other two are non-energy sectors. There are four types of direct coefficient in the matrix A* ,viz; (1) Mtoe/Mtoe = the Mtoe required as inputs from the energy sectors to produce a unit of Mtoe output, (2) Mtoe/Rs = the Mtoe required to produce one unit output of non-energy sectors measured in value terms, (3) Rs/Mtoe measures the Rs cost of non-energy sector input per Mtoe of output from the energy sector and (4) Rs/Rs is the standard direct input-output coefficient indicating direct input from the non-energy sector to produce one unit worth of output in the non-energy sector.

Using the above mentioned matrices, we can rewrite the energy balance condition of equation 2.24 as

$$eA^* X^* + e Y^* = e X^*. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.29)$$

where e is a diagonal matrix composed of ones and zeroes. The ones appear in the column locations that correspond to the energy

sector and all the other elements of the matrix are zeroes. The matrix selects the energy rows from the input-output tables.

We can now obtain information about the amount of intermediate energy required in the economy, by combining and rearranging equation (2.24) and (2.29) to give

$$E_i = eA^* X^* = e\ [(I-A^*)^{-1} - I]Y^*. \quad \ldots\ldots\ldots\ldots\ldots\ldots (2.30)$$

Then, to calculate the direct energy consumption, E_y, we need to adjust the final energy consumption for energy export, import and inventory change. Mathematically, we have

$$E_y = E_d + E_u + E_v - E_w \quad \ldots\ldots\ldots\ldots\ldots\ldots (2.31)$$

where E_d is the vector of final energy consumption, E_u is the vector of energy net inventory change, E_v is the vector of energy exported, and E_w is the vector of energy imported from other countries to meet the deficit.

The total energy consumption, E, in the economy is the sum of intermediate and direct energy consumption, i.e

$$E = E_i + E_y = e[(I-A^*)^{-1} - I\ ]Y^* + eY^* \quad \ldots\ldots\ldots\ldots\ldots\ldots (2.32)$$
$$= e(I-A^*)^{-1}\ Y^* \quad \ldots\ldots\ldots\ldots\ldots\ldots (2.33)$$

Hence equation 2.33 shows that the total energy consumption in an economy is determined by the total intermediate energy requirement and the direct energy requirement by the final demand(Y). In equation 2.33, $e(I-A^*)^{-1}$ gives the direct and indirect energy required to produce one unit worth of output for final demand in a particular producing sector.

2.2.1. Studies based on Input-Output model.

The Hybrid's formulation as discussed in the previous section have been used in subsequent studies by Bullard et al.(1978),

Blair(1981), Casler & Wilbur(1984), Peet(1986), Gowdy and Miller(1987), Casler and Hannon(1989), Hwa - Rang and Chen Yen(1989), Han and Lakshmann(1994), and Lin & Polenske(1995).

On the hypothesis of invariance of technical coefficient, one can project forward or predict backward in time, the gross output level, given the final demand. A comparison of gross output thus obtained with the actuals will show structural change and comparison with those obtained on alternative models will show the prediction accuracy of the input-output model. This approach is due to Leontief(1960) who carried out backward prediction for the years 1919 and 1929 by using 1939 technology matrix and compared the results with the projected GNP for the American economy.

Literature on the subject,besides the GNP projection approach, which forecasts that the gross output of each industry will change from the base period in the same proportion as the GNP, provides two more bases for appriasing the prediction by the I-O model. One such is the final demand projection which forecasts that the output of each industry will change from the base period in the same proportion as final demand for that industry. Another is the multiple regression of the output of GNP and the time which forecasts that the gross output of each specific industry is linearly related to GNP and time. Arrow and Hoffenberg's study(1959) of the American economy for the same period as that by Leontief but at a more disaggregated level, compares the input-output estimates with the above mentioned models. Other studies giving account of similar tests are by Cornfield, Evans and Hoffenberge(1947), Arrow(1951), Chenery, Clerk, and Cao-pinna(1953), Barnett(1954),Sevaldson(1956), Shishido(1957), Hatanaka(1960), Matuszewski et al(1964) and Tilans(1966). Most of the studies found projection on the basis of input-output models to be more accurate than projection on the basis of other alternative technique. As the input-output projections are better than the other alternatives we can also rely on it for the projection and prediction of energy uses or requirement with no doubt.

The above studies merely compare the gross output estimates as obtained from the input-output model with the actual to estimate the structural change. There are several studies which attempt to factor out the total structural changes according to causes of changes viz; technological change and final demand change. The methodological framework in these studies are largely the same. One of the first studies of this kind is by Vaccara and Simon(1968) for the American economy for the period 1947-64, which uses three point Input-output data for 1947, 1958, and 1964 all valued at the 1958 constant price base and factors out structural change into components in two sub periods 1947-58 and 1958-64. The other studies of similar nature are by Leontief(1953), Rasmussen(1956), Chenery(1960), Chenery, Shishido and Watanabe(1962), Watanabe(1969), Carter(1967, 1970, 1980), Vaccara(1970), Staglin and Wessels(1972), Armstrong(1974), Venkatramaiah and Argade(1979), Guill(1979), Feldman and Palmer(1985), Urate(1988), Foresell(1988), Blain and Wyckoff(1989), Dhawan (1993). The above studies of structural decomposition analysis involves analysis of economic changes by means of a set of comparative static adjustments of key parameters of input-output table(Rose & Miernyk, 1989).

In recent years, the structural decomposition Analysis has been widely used in energy studies also. For instance Strout(1966) analysed how changes in technology and in the level of composition of final demand affected US energy use between 1939 and 1954. Reardon(1976) conducted an input-output analysis of energy use changes for 1947-58, 1958-63 and 1963-67. With an input-output framework , Park(1982) measured the direct, indirect and income induced energy effects of a change in final demand, and estimated the effect of technological change on energy consumption. Ostbolm(1982) attributed the change in the energy output ratio of the Swedish economy to changes in direct energy coefficient, changes in output share of industrial sectors and changes in the composition of final demand. For the USA in 1963 and 1980, Hannon(1983) compared the energy costs of providing goods and services. Proops(1984) decomposed changes in the energy output ratio into three factors: changes in energy intensities,

changes in final demand; changes in the structure of inter-industry trading. For Danish manufacturing industries, Polger(1985) assessed the effect of changes in the output mix and energy coefficients on energy consumption. Casler and Hennon(1989) examined the readjustment potential in the industrial energy efficiency and the structure in the USA. Rose and Chen(1991) made a major contribution to advance the state of art of structural decomposition analysis to a two-tier KLEM(Capital, Labour, Energy, Material) flexible production function framework, which produced 11 separate sources of energy use change and three "substituting" effects. Applying their model to study energy demand changes in USA for the period 1972-84 (Rose and Chen,1991) and that to Taiwan(Rose and Chen,1990) between 1971 and 1984 showed that, over all, the model can yield as much insight as more elaborate and data intensive KLEM econometric models of production technologies. Of late Lin and Polenske(1995)has developed an alternative to the KLEM of Chen and Rose and analysed the energy use changes of China in 1980's. Instead of KLEM production framework they decompose the final demand changes based on changes in level, mix of spending and distribution of final demand by different final users. Using this methodology they found that the driving force of energy intensity decline was energy efficiency improvement- the reduction in direct energy coefficient in most production sector- which were multiplied across the entire economy through inter-industry input-output linkages. But the main limitation of the above studies are that the interaction effects are over looked. The mathematical formulation to factor out the changes in the energy level into different components in the above studies are as follows.

The mathematical formulation to factor out energy use changes into different components is of the following type:

$$dE = eR_t^* - eR_o^*$$

$$= e(R_t^*Y_t^* - R_t^*Y_o^*) + e(R_t^*Y_o^* - R_o^*Y_o^*) \quad \ldots\ \ldots\ldots\ \ldots\ldots\ldots\ldots (2.34)$$

or $$dE = (D_tR_tY_t - D_oR_oY_o) + S\ Y_t - S\ Y_o$$

$$= (D_tR_tY_t - D_tR_tY_o) + S\ (Y_t - Y_o) + (D_tR_tY_o - D_tR_oY_o) +$$

$$(D_tR_oY_o - D_oR_oY_o) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.35)$$

where dE represents the change in output between period t and o. R the Leontief inverse matrix and Y denotes the final demand vector R^* and Y^*. are the counterparts in the hybrid units' model. The equation 2.34 shows the change in energy use with the help of hybrid units' model while equation 2.35 shows the same through the conventional energy model.

In the above described formulation the main drawback is that of the indexing. In the chapter 5 we have mentioned the limitation of all the above measures and also discussed the measure we have adopted to meet the objectives of the present study.

2.3. Objectives of the study.

The specific objectives of the present study are as follows:

Energy consumption typically grows faster than final economic output in the developing countries. This change may as Lin and Polenske(1991. 1994) have noted, occur as a result of at least six major changes associated with development: industrialisation, increase in the capital-labor ratio, substitution of commercial energy for traditional energy, the construction of modern infrastructure, motorisation, urbanisation. Levien et al (1991) found that, energy consumption for the developing countries as a whole grew by 20% more than did the gross domestic product(GDP) during the period between 1972 and 1988. Schipper and

Meyers(1992) similarly reported that, for most of the past 20-30 years, commercial energy consumption increased more rapidly than the GDP in the developing countries. Imran and Barnes(1990), Polenske and Lin(1991,1995) are of the same view about the energy change.

Hence the first objective is to analyse and measure the energy demand of different sectors of the Indian economy over the time period 1979-80 to 1991-92. The analysis is based on the Input-Output tables of the years 1979-80, 1984-85, 1989-90 and 1991-92 as prepared and published by the PPD of Government of India and the energy data provided by CEA, Ministry of Petroleum and N.Gas, Coal India Directory. To analyse the importance of energy in different sectors we made an attempt to first study the energy intensity of different sectors for different sources of energy, the direct and indirect use and change in energy use over different years. Secondly, the share of energy in cost pricing has been determined. In other words, we try to find out the share of energy in the cost of producing output of different sectors of the economy over the same period. The entire period of consideration is divided into three sub periods, the first ranging from 1979-80 to 1984-85, the second ranging from 1984-85 to 1989-90 and the third ranging from 1989-90 to 1991-92. The analysis has also made for the whole time period ranging from 1979-80 to 1991-92. By looking into both the sub periods and the whole period as such, we can have an insight into both the short term and long term factors influencing the energy demand of different sectors. Further, the parameters such as change in energy use, cost shares and intensity have been decomposed into different sources of change. For instance the change in energy use of different sectors have been decomposed into the change in the technology of the economy, change in the final demand and the growth of final demand over the years. Here it should be noted that the final demand effect is further decomposed into categories of final demand effect. Changes in the cost share of energy of different sectors are the result of two main effects such as effect of change in the value added and the effect of change in intermediate input coefficient or technology. Such an attempt

indicates how important a particular energy source is and how its importance is changing over the years under study and which factors affect the change to what extent can also be judged from this study using input-output technique. These issues will be discussed in detail in the ensueing chapters.

The aim and policies of the government relating to the energy sector should be such that it would not stand as an obstacle to the rapid economic growth of the economy. In fact, the main emphasis in our five year plans has all along been placed on achieving the highest rate of attainable growth with stability. In the light of the above objective, the aim of the present study is to find out whether the relationship between energy use changes, and economic growth of the Indian economy over the period under study has been significant or not. The findings in this context can prove to be very useful for the planners and policy makers, in the sense that quantitative assessment of various factors affecting energy consumption is essential not only for a better understanding of past behaviour of energy consumption but also for forecasting industrial energy demand, and particularly estimating energy requirement of alternative industrialisation strategies in developing countries.

Thus the main objectives of this study are to ascertain the energy use and intensities of different sectors of the Indian economy over the period and then to factor out the different sources of change over the same period.

CHAPTER 3

THE DATA

This chapter is devoted to explain in detail, the various sources of data collected for this study, their special characteristics, limitations and vintage.The method applied to make various data comparable and applicable to the present study is also presented in detail.The basic data for this study consisted of Input-Output Tables, Import-Transaction and Import-Coefficient Matrices, Employment Matrix and Price and other Indices etc. The Input-Output tables, Import-Transaction (Coefficient) Matrices, the prices, employment data and some other data available from different sources were used with some modifications and adjustments which are presented in the following paragraphs.

The first section discusses the form of Input- Output tables as available from the source and the modifications done to make these comparable with the underlying assumptions. This section also deals with the principal characteristic of the Indian Input-Output tables. In the second section of this chapter we discuss the issue of the inter temporal comparability of these Input-Output tables and the adjustment made to these data to make those consistent with each other. The third section describes the other data sources e.g. for prices, implicit value indices, implicit unit value indices, employment in various sectors. The various methods used to modify these data are also explained in this section.

The basic data for this study is provided by the 1979-80, 1984-85, 1989-90, and 1991-92 Input-Output tables prepared by the Planning Commission for the 5th, 6th, 7th, and 8th five year plans. Besides the Input-Output tables of the Planning Commission, we made use of the data provided by other sources like Coal India Directory for coal, Petroleum & Natural Gas Statistics

for crude oil, petroleum products and natural gas and Central Electricity Authority(All India Statistics) for electricity.

3.1. Principal features of the Indian Input-Output Tables•

The Input-Output tables used in this study may be described as open, static, Leontief table. The first Input-Output transaction table (IOTT) consistent with the National Accounts Statistics related to the year 1968-69 was prepared jointly by the planning commission and Central Statistical Organization (C.S.O) and published in the National Accounts Statistics. Later C.S.O undertook the responsibility to prepare the I-O tables from the year 1973-74 onwards on a quinquennial basis, while Planning Commission uses the I-O tables prepared by the CSO to update and prepare modified set of I-O tables for the base year and projected tables for the end year of every Five Year Plan (FYP). Besides this Planning Commission prepares and publishes regularly (corresponding to every FYP) the Import-Transaction (Coefficient) matrices. Therefore, the I-O tables prepared by the Planning Commission for the years 1979-80, 1984-85, 1989-90, and 1991-92 form the main source of data for the purpose of this study as provided in the technical notes to Sixth, Seventh, and Eighth plans.

The Input-Output transaction tables as provided by the Planning Commission for the references years were in the form of Absorption (commodity x industry) matrices at the current factor prices. Reading down any column of this Absorption matrix shows the group of the commodities which are the main products of the industries showed along the column. Reading from left to right along any particular row, we see that part of the total output of that commodity is sold to other industries for their intermediate consumption in the production of their principal commodity. On the other hand, the rows in the final use part give the use of commodities used by final users, e.g. private households, government, investment, foreign trade. The total output in a row, thus represent the total use of a commodity in intermediate use and final use, which is equal to total output of that commodity in the economy, net of imports. The column

entries at the bottom of the table (quadrant III) give the primary inputs in terms of value added from use of labour, capital and net indirect taxes (i.e. indirect taxes less subsidies). The entries read down industry columns give the commodity input required to deliver the output of that particular industry. As in the ordinary Input-Output table, the column entries in the bottom show the gross value added for the three reference years, which includes not only the remuneration to the primary factors but also the indirect taxes.

One thing to be noted in these reference Absorption matrices is that the column sums i.e the total commodity output does not tally with the row sums or industry output due to the inclusion of the secondary products in case of the manufacturing sectors. While the columns of the absorption matrix show not only the main products but also the by-products, the rows of the absorption matrix shows only the main product. While determining the entries in the rows, a by-product of an industry is transferred to the sector(commodity row) whose principal product is the same as by-product under reference, which creates the difference between the row sums and column sums.

The detailed Input-Output transaction table (Absorption Matrix) of 1979-80 has been constructed by taking into account the 225 sectored Input-Output table of 1968-69, which has been constructed by the Perspective Planning Division in collaboration with the Central Statistical Organization. The 1968-69 table has been first aggregated to 89 sectors and then the later was updated to 1979-80 at 1979-80 prices using the available information on input norms, commodity output levels, exports, imports, investment, public and private consumption and 1979-80 price indices. As far as the 1984-85 table is concerned it is based on the 115 sector Input-Output table for the 1973-74 of C.S.O. duly updated and revised as the 1979-80 table. Though here an attempt has been made to present the four reference Input-Output tables by 46 sector classification, the sector classification of 1984-85, 1989-90, and 1991-92 which are exactly identical differs slightly from that of the 1979-80.

The final demand in all the four reference years has been distinguished under six heads

(1) private final consumption expenditure(PFCE),

(2) government final consumption expenditure(GFCE),

(3) gross fixed capital formation(GFCF),

(4) change in stock(CHIS),

(5) export of goods and services(EXP) and,

(6) import of goods and services(IMP)

The PFCE includes expenditure of resident and non-resident households in the domestic market and non-profit institution. GFCE has been treated as current consumption expenditure of the Government which comprises the compensation of employees, depreciation and intermediate consumption. CIS includes semi-finished goods, the part of the output being hold by sectors producing these outputs and hence these are free of trade, transport margins and net indirect taxes. Export has been considered as demand of domestic output by foreign countries which comprises merchandise, f.o.b and other items like transport and communication in respect of exports other than merchandise, insurance etc. Imports are taken at c.i.f values and included in final demand as negative entries.

All the entries in the three reference IOTT are at factor cost, that is, excluding trade and transport charges and net indirect taxes (indirect taxes less subsidies). The Input-output transaction tables to begin with were prepared at original purchase price, that is, at the price in which the actual transaction took place. The entries at the factor cost were arrived thereafter by removing the components of trade and transport margins and indirect taxes. These components have been shown in separate rows in the tables. The rows of the net indirect taxes depicts the taxes paid by the industries on intermediate inputs used in the process of production of industry's output. The matrix of net indirect taxes is obtained by adding the individual matrices of import duty, excise duty, export duty, sales taxes and other taxes and subtracting the matrix of subsidies.

The above analysis is on the basis of absorption matrix recording the input of commodities into industries of the four reference years. Other matrix which provides the basic information to the Input-Output system is the make (industry x commodity) matrix. The Make Matrix (Industry x Commodity) represent the distribution of the production of an industry into commodities, which are the main products of various industries. This is in the form of inter-industry table only and no final demands are given for this. The coefficient matrix of this table is prepared with the help of proportions of production of an industry into commodities produced as the main products of various industries. Now the construction of the pure tables viz; commodity x commodity or industry x industry from the basic data involves transfer of inputs and outputs between sectors and such transfers are in fact possible by suitably combining make matrix and absorption matrix under the appropriate assumption adopted by C.S.O for the four reference years. In the construction of industry x industry and commodity x commodity matrices from the basic tables of make matrix and absorption matrix, the secondary products of manufacturing industries have been transferred to the industries where they are primarily produced. The two alternative assumption for transferring of outputs of secondary product are (1) the industry technology assumption where input structure of a secondary product is considered to be similar to that of the industry where it has been produced and (2) commodity technology assumption where the input structure of the secondary product of an industry is assumed to be similar to that of the industry where it is primarily produced. In a commodity x commodity table both rows and columns represents the commodity group sectors. If the secondary products of an industry group along with the inputs transferred to the industry group where they are the principal products, the resulting table is a commodity x commodity input-Output table under the industry technology assumption. Thus the analysis presented in the following chapter have been based on the commodity x commodity Input-Output tables based on the industry technology assumption adopted by C.S.O. This is preferred over other tables as it is found to be more suitable in most application since demand is for a particular

commodity or group of commodities and not for fixed range of output of an industry.

Since the basic purpose of this study is to analyse the energy sectors of the Indian economy, the Commodity * Commodity table reflects the technology of production in an appropriate manner from demand sides. Further the basic equation of Input-Output theory i. e.

$$X = (I - A)^{-1} F$$

holds only in the case of pure tables like the one specified by a Commodity * Commodity table.

3.2. Comparability of the Input-Output Tables.

Since in this study we basically used the four reference Input-Output tables of 1979-80, 1984-85, 1989-90, and 1991-92, the overall value of this research depends on the comparability of these four tables. Accordingly in this section, an attempt has been made to discuss the comparability of the four Input-Output tables, identify those factors which tend to reduce the comparability of those tables and then explained the adjustments that were made to improve the comparability of the transaction tables.

First, the Input-Output tables presented by the Planning Commission of India for various plan-periods follow different sectorisation pattern. While the tables for 1979-80 had 89 * 89 sector pattern, that of 1984-85 had 50 * 50 classification; for 1989-90, and 1991-92 follow 60 * 60 sectorisation pattern. Since, there was wide difference in the sectorisation and lack of information on employment and prices for very detailed classification, all the tables were aggregated into a common 46 * 46 sector classification (given in table 3.1). This sectorisation is quite useful to analyse the policy changes in energy sectors, because most of the major items and industries involved in the production and/or consumption are easily distinguished in this classification.

As some sectors comprise of several commodities, services or articles for which the price index are not available, we have tried to overcome the problem by merging that sector with a mother sector for which the price index is available. For example, as the price index for the sector namely textile products is not available, we resolved the problem by clubbing this sector with the sector i.e. jute,hempa and besta textile whose price index is readily available. For the same reason we got the sector (i.e wood and wood product) (i.e paper and paper based industries) and (basic heavy chemicals) by clubbing the sectors of C.S.O and Planning Commission.

Sector 38 of our study (i.e transport equipments and miscellaneous manufacturing) was clubbed for a slightly different reason. The reason is that the Planning Commission Input-Output transa. ction tables were basically developed or updated from the C.S.O tables and in C.S.O classification itself the aircraft sector is classified differently in 1968-69 and 1973-74 tables as compared to 1979-80 and 1983-84. In the former two tables 'aircraft' was included in sector 43 (i.e in other transport equipments) of C.S.O while in the latter two tables it was included in sector 44 (i.e in the miscellaneous manufacturing sector) of C.S.O.

Secondly, it has to be noted that the four basic Input-Output tables of 1979-80, 1984-85, 1989-90, and 1991-92 are constructed at the current prices. So, before the four tables were used for analyzing the trends of energy intensity change in the Indian economy, a number of initial adjustments were made to make it more comparable over the years. Now, since the Input-Output tables are at current prices, the cell entries of the Input-Output transaction table does not give a correct picture about growth of the economy as increase in the figure may be due to, beside other factors, (a) an increase in inflation rate (price level) or (b) an increase in the production and usage of real goods and services. If the increase in entries are due to an increase in production and usage of goods and services, then this shows a real development. But in developing countries like India, the first factor always plays a vital role, which

Table 3.1 Sectorisation of the Indian Economy

S.No.	S.No.in 50*Sector.	Production Sector	Sector Content
1.	1,2,3,4	Foodgrains	Paddy,Wheat,Coarse- grains,Gram and Pulses
2.	5	Fibre Crops	Cotton and Jute crops
3.	6	Plantation Crops	Tea and Coffee crops
4.	7	Other Crops	Sugarcane,Groundnut, Rubber, Coconut, Tobacco, Oilseeds, Vegetables, Spices, Fruits and Nuts, Agri-by products
5.	8	Animal Husbandry	Milk,Milk products,meat,eggs and other animal products
6.	9	Forestry & Logging	
7.	10	Fishing	
8.	11	Coal & Lignite	
9.	12	Crude Oil & Natural Gas	
10.	13	Iron Ore	
11.	14,15	Other Metallic, non-metallic and minor	Manganese, Bauxite, Copper, Silver,Gold,limestone,minerals, Mica, Diamond, Silica, China clay Asbestos, Gypsum, others
12.	16	Sugar	Production of Vacuum Pan Sugar
13.	17	Khandsari ,Gur and Boora	Production of indegenous open pan sugarcane,Palm sweeteners
14.	18	Other Food and Beverage	Industries Tea,Coffee processing Vegetable Ghee,Edible oils, Beverages, tobacco and other food products
15.	19	Cotton Textiles	Including Khadi,Handloom and Powerloom
16.	20	Art Silk & Synthetic Textiles	
17.	21	Woollen Textiles	

18.	22	Other Textiles	Jute,Hemp and Mesta textiles, Carpet, Readymade garments,Coir Products,Linoleum hats, Raincoats, Rubberised cloth
19.	23	Wood and Wood Products	Including Furniture,construction materials
20.	24	Paper and Paper based Industries	Pulp,Paper,Printing and Publishing,Newsprint
21.	25	Leather and leather based Industries	Including Footwear,apparel
22.	26	Rubber Products	
23.	27	Plastics	
24.	28	Petroleum Products	
25.	29	Coal Tar Products	Including Coke
26.	30	Fertilisers	
27.	31	Pesticides	
28.	32	Synthetic Fibre & Resin	Paints, Varnishes, Lacqures, Soaps, Cosmetics,Glycerine
29.	33	Other Chemicals	Including Matches, Explosives, Drugs, Dyes and Glue
30.	34	Cement	
31.	35	Other Non-Metallic Mineral Products	Glass Products, Earthern ware, Sanitary wares,Stone ware, Asbestos Cement Products, Slate, Graphite, Optical Products
32.	36	Iron & Steel	
33.	37	Non-Ferrous Metals	
34.	38	Non-Electric Machinery	Air conditioners, boilers, Diesel Engines,Air-compressors,Ball and Roller bearings,Washing Machines Drills,Earth moving Cranes, Conveyors, Road Rollers, Construction and Mining Machinery, Handtools, Containers, Polishing Utensils Cutlery,Metal
35.	39	Electric Machinery	Generators,Transformers,Insulated cables,Batteries,Cells,Fans, Lamps, Tubes, Heaters,X-ray Eqpts.,Light Fittings,Household appliances.

36.	40	Rail Equipments	Locomotives
37.	41	Motor Vehicles	Motor cars, Buses, Trucks, Jeeps, Motorcycles and Scooters
38.	42	Other Transport Equipments	Bicycles,Ships,Boats,Bullock carts, Tongas, Carts, Rickshaws
39.	43	Communication & Electronic Equipments	Wireless communication, Radios, Teleprinters, Telephones, Telegraphs, computers, T.V, Control Equipments.
40.	44	Other Manufacturing	Watches,Clocks,Medical Equipments, Weights and Measures,Sports, goods,pens, Advertising aids, Toys, Ivory, Wigs, Jewellery,Badges,Aircrafts, Scientific Instruments, Meters, Photographic instruments, Coins
41.	45	Rail Transport Service	
42.	46	Other Transport Service	Air, Motor, Water and Animal based transport services
43.	47	Electricity	Generation, transmission and distribution of electricity
44.	48	Construction	Including Rail Construction, Hydel reservoirs, Land improvements in farms and in forests, forstation
45.	49	Communication	Communication service only
46.	50	Other Services	Gas,Water Supply, Storage, Ware-housing, trade, Hotels and Restaur'ants, Banking,Real Estate, Education, Research, Medical Legal, Recreation, Relegious, Domestic, Laundry, Barber, Dying Sanitary services,Public Admin., Defence, Police

* Planning Commission Classification.

unnecessarily gives an aggravated number. So in order to deal with the price increase and to make the table more comparable, the first adjustment made was the conversion of the four Input-Output tables from current prices to constant prices. For the purpose of the present study , it was decided to take 1984-85 as the base year in order to eliminate the effects of change in price level during the period under study. So the 1979-80 Input-Output table was inflated to 1984-85 price level while 1989-90, and 1991-92 Input-Output tables were deflated to the same period. 1984-85 has been chosen as the base year because this is the most recent years analyzed which is normal and also because of the necessary price index required for deflation exercises are available for this year.

3.3. Energy Sector Data.

It has been explained in chapter 2 that our main emphasis is on the Hybrid unit's model. In the Hybrid unit's model the first four energy rows are in terms of physical units and the remaining sectors in value terms. The four sectors measured in physical units are inserted into transaction matrix. In other words the energy requirement matrix of order 4 x 46 describes the sectoral requirement levels in terms of physical units by each sector for production of that sector's total output. The construction of an energy flow matrix, however, requires a big data base which is very difficult to obtain in a country like India. As a result of which we had to make certain adjustments in preparing energy flow matrix in physical units. The main sources of data for this study were The Coal India Directory(1979-80,1984-85,1989-90, and 1991-92) for coal, Petroleum and N.Gas Statistics (1979-80,1984-85,1980-90, and 1991-92) for petroleum products,crude oil and n.gas. Central Electricity Authority (All India Statistics) and ASI reports for electricity consumption. Besides, the information provided by the technical notes of Five year plans were also used to some extent to solve the data problem.

However, the data on energy consumption (in physical quantity) provided by the above sources were not in a sufficiently detailed sectorisation. To solve this problem we had to undertake the following exercises. As far as coal is concerned, data provided by Coal India Directory (which is the only source to provide in physical quantity) was only for certain important sectors viz. (1) steel and washery, (2) railways, (3) electricity(excluding middlings), (4) cement, (5) cotton, (6) jute, (7) bricks, (8) paper, (9) coal for soft coke, (10) colly's consumption, (11) other industries. Since the other industries which consist of 36.64 Million Tonnes i.e 18% in 1989-90 includes the rest of the industries, we divided this among the rest of the industries by using the proportional method. For instance, suppose the share of the sector, say i, for which the quantity data is not available, in the total value of output be X%, then the quantity of coal allocated to this sector would be X% x 36.64 Million Tonnes in 1989-90. Similar adjustment was made to other industries and for the four reference years for which the I-O tables were available.

Similarly, as far as Petroleum and N.Gas was concerned , the data provided by Indian Petroleum and Natural Gas Statistics(which provide data in physical quantity in some detail) gave data for the sectors viz; (a) transport: (1) road transport, (2) aviation, (3) shipping, (4) railways, (5) other transport (b) plantation/food (including processing): (1) sugar mills, (2) others (c) power generation(utilities), (d) industry: (1) iron & steel, (2) textile & fiber, (3) cement, (4) ceramics and glass, (5) chemicals and allied, (6) aluminium, (7) mining and quarrying, (8) engg(mech & elec), (9) fertiliser, (10) other industries and construction, (e) misc.services. Since here also, as coal, the sectorisation data is not complete, the same proportionality rule is adopted to find out the share of sectors for which data was not available.

However, for electricity, we did not have to face much problem as the data for industries were available from ASI report in detailed classification. And as far as agriculture,

transportation and commercial purpose is concerned, we made use of the data provided by Public Electricity Supply (All India Statistics),published by Central Electricity Authority.

Once the energy flow matrix was obtained ,the next adjustment made was with respect to units. It is to be noted that, the units of different sources of energy were different, for instance, coal was measured in million tonnes, electricity was measured in GWH(or KWH), while crude oil and N.gas and petroleum products were measured in million matric tonnes (MMT). So in order to make all the sources consistent we made use of the conversion factor as provided by the Fuel Policy Commission, 1974. In this study the conversion factors were expressed in oil equivalent terms. Energy data in India have been compiled in oil equivalent units, as opposed to oil replacements units or other units that measure the calorific content of an energy sources. The conversion of energy demand data into equivalent units is a two step process : (1). measuring useful energy per unit of a particular fuel for a given end-use;and (2). estimating the quantity of oil required to obtain the same amount of useful energy in the same end-use.

For example consider a fuel, f, of the energy content X kcal/kg, used with an efficiency e_f in a particular end-use. To find the oil equivalent value, let oil of energy content 5000 kcal/kg, be used with efficiency e_o in the same end-use. The oil equivalent can be worked as follows :

useful energy in kcal from one kg of fuel f

$$= \text{efficiency of f x energy content} = e_f \times X$$

and useful energy kcal from one kg of oil

$$= \text{efficiency x energy content} = e_o \times 5000.$$

Therefore, the oil equivalent unit for fuel f = $(e_f \times X)/(e_o \times 5000)$ kg of oil.

The conversion factors which are used in this study are given in the Table 1.6. -

3.4 Other Data Sources and Adjustments.

The other data which were utilised for this study include data on employment, prices,other indices, factor income distribution, income distribution from the value added generated in various sectors into income-groups and distribution of various commodities into income-groups of households for final consumption etc. For data on employment, the information about sector-wise employment at 3-digit levelof NIC was obtained from National Sample Survey Organisation (NSSO) for 32nd round (for the year 1977-78) survey, 38th round (for 1983) survey and 43rd round survey (for the year 1988). For the latest information about employment at the main activity level 1 of NIC the information as available from 1991 census was used with the break-up as available from the 43rd round survey of NSSO.The estimates for the mid-year of the years 1979-80, 1984- 85, 1989-90, 1991-92 were prepared based on interpolation and extrapolation method with the help of available data for three points of time as described above. Since the employment data are not available on the pattern of employment-industry matrix, a vector of Labour- Output Coefficient for each year 1979-80, 1984- 85, 1989-90 and 1991-92 was derived with the help of sector-wise employment and total sectoral output during the respective years. For some sectors , the information on employment was required at four digit level of NIC e.g.Cement; for such sectors the division of employment was done on the basis of corresponding ratio in employment obtained from latest detailed ASI results (Item-wise)

The next important data are price-data,which were required for inflating/deflating all the Input-Output tables, Import-Transaction matrices to a common time period, for estimating the Fixed Capital Stocks at constant prices by the PIM and the Gross Value Added (GVA) etc.The information on Whole-sale Price Indices was obtained for various years at the detail-item level from the" India Data Base",Council for Monitoring the Indian Economy (CMIE) publications regarding Economic Adviser's Whole-Sale Price Indice (WPI).For various services sectors, the

implicit deflator for estimating the GVA at constant prices in CSO has been used, which was derived from various issues of the NAS for the relevant years. Since the price indices for intermediate consumption do not vary at the similar rate as those for the private consumption or the investment, separate price indices/ implicit deflators were used converting the intermediate consumption, final demands for the same commodities as given below:-

(i)	For intermediate consumption of various goods and services	Economic Adviser's Wholesale Price Index
(ii)	For Private Consumption	C.S.O.'s Commodity-wise implicit deflator
(iii)	For Fixed Capital Formation	- do-
(iv)	For Govt. Consumption	- do -
(v)	For Change in Stock	- do -
(vi)	For Indirect Taxes	- do -
(vii)	For Gross Value Added	- do -
(viii)	For Imports	DGCIS' Unit Value Index of Imports
(ix)	For Exports	DGCIS' Unit Value Index of Exports

For the items which were imported in significant proportions, the weighted index of whole-sale and Unit Value Index of Imports was used to bring the prices at the comparable level e.g. crude petroleum, fertilisers etc. For bringing the GVA in the primary inputs to the constant (1984-85) prices, the implicit price deflator for GVA as applied by CSO in NAS was used for various sectors as available in disaggregated statements for different years. The conversion of Net Indirect Taxes (NIT) to constant prices was done as a residual after converting all the other entities and the totals. Firstly, all the values in the inter-industry transaction matrix were converted to constant prices by the use of various indices as given above, then all the values in the final demand vectors were converted to constant prices with the help of appropriate indices as

mentioned above.Thus the value of Gross Output was evaluated at constant prices.By using the Gross Output at constant prices, the intermediate supply to various sectors and the GVA, the NIT were estimated at constant prices as remainder.

The whole matrix of Import-Transactions was converted to constant prices with the help of Unit Value Index of Imports as available from the Directorate General of Commercial Intelligence and Statistics (DGCIS).The year for common price level chosen was 1984-85 for all the periods and for all the entities.For converting the price level of some specific categories, which are based on weighted indices of many items of goods, services(e.g. Construction, Buildings, etc) the cost of construction index and cost of building index made by commodity flow method in CSO were used.

Although every effort has been made to make the price comparable for all the tables meant for different time- periods, still some incomparability might have been left in the tables. Besides, the information on Unit Value Indices of Imports and Exports were available at broad item level, which was not so appropriate to convert the prices in some sectors. Still in such statistical exercises certain incomparability cannot be ruled out. Therefore, the results of this study may be considered with due acknowledgement of such inconsistencies, incompatibility and incomparability as might have been left in these tables, matrices and other data.

CHAPTER 4

ENERGY INTENSITY ANALYSIS

With the transformation of the Indian economy from a primarily agricultural state to a modern industrial one, the energy consumption grows faster than the final economic output like in other developing countries. As Lin(1991, 1994) and Polenske and Lin(1993) discussed this change in energy intensity may be attributed to at least six major changes associated with development; industrialisation; increase in capital-labour ratio; substitution between traditional and commercial energy sources; the construction of modern infrastructure; motorization; and urbanization. During the past two decades the government has been committed to the development of energy technologies, the promotion of conservation, and the restructuring of energy supply to reduce the rate of energy use and the dependence on foreign oil. The effectiveness of these efforts will be the basis of major policy guidelines for the future. It is therefore, very important to determine the impacts of past policies, and the extent to which they have been reinforced or offset by secular and cyclical economic phenomena.

Unfortunately, the absence of relevant Input-Output tables limits the detailed investigation of energy intensity changes in the Indian economy from the period 1979-80 to 1991-92 only. As mentioned in chapter 2 the choice of the above period is purely dictated by the availability of Input-Output tables.

In this chapter we shall analyse the energy intensities of different sectors of the Indian economy over the period 1979-80 to 1991-92. The analysis will cover the overall period of 1979-80 to 1991-92 as well as the subperiods, and thus will be able to yield insight into both short-run and long- run responses. This chapter has been divided into five sections.The methodology used in the

analysis is presented in section 4.1. Section 4 2 analyses the direct energy flows and intensities of different sectors over the period of 1979-80 to 1991-92, while in section 4.3 the total(direct + indirect) energy intensities of different sectors and the change in intensities over the sub-periods and the whole period has been analysed. The energy intensities in the final demand categories has been discussed in section 4.4 and finally section 4.5 presents a summary of this chapter.

4.1. Methodology.

In this chapter we propose to analyse the energy intensities of different sectors of the Indian economy for the years 1979-80, 1984-85,1989-90 and 1991-92 and the changes in intensities over the whole period of 1979-80 to 1991-92 and the sub-periods. As discussed in the previous chapters energy intensities represent a set of measureable coefficients of the energy required to.produce a unit of output of goods and services.These coefficients are of fundamental importance in energy analysis. Various measures for the energy intensities have been suggested, of which the Input-Output(I-O) technique has gained considerable attention in developing countries. The I-O technique in contrast to other conventional process of energy analysis, can efficaciously provide a panorama of both direct and indirect energy flows throughout the entire economic system. Besides energy-intensity analysis is a prerequisite exercise for the discussion of structural decomposition analysis(SDA) of a particular nation.

Here in the analysis we use the Hybrid unit's formulation of the energy I-O framework adopted from the work of Bullard and Hereenden(1975) and Bulard et al(1978), and replace all the energy rows in the monetary input-output table with energy in physical flows. Miller and Blair(1985) demonstrated that the Hybrid units formulation is generally superior to the output conversion approach, because it always conforms with energy conservation conditions. The model is described in detail in the chapter 2.

Once the $(I-A^*)^{-1}$ is obtained, then the total energy-input matrix T is formed in the following manner,

$$T = e \quad (I-A^*)^{-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.1)$$

which simply retrives the energy rows of the $(I-A^*)^{-1}$ matrix, where e is a vector of total energy consumption, the elements of e are zero for non-energy producing sectors, X is the diagonal matrix of gross output, T is the total energy matrix, an element t of T_{ij} represents the direct and indirect energy i required to produce one unit of final demand of product j. Or in other words T_{ij} represents energy of type i intensity of a unit of product j.

4.2. Direct Energy Intensity.

In this section we examine the direct energy intensities of different sectors of the Indian economy for the years 1979-80, 1984-85,1989-90, and 1991-92, while in the next section we analyse the total(both direct and indirect) energy intensities of all the sectors in the same years. As explained, energy intensity of a particular sector is defined as the energy requirement for the production of one unit of output of that sector. Tables4.1 to 4.4 show the direct energy flows of the 46 sectors in the year 1979-80, 1984-85, 1989-90, and 1991-92 respectively. Here it should be noted that all the energy sources viz; coal, crude oil & N.gas, petroleum products, electricity are expressed in the same units of Thousand Tonnes of Oil Equivalent(Ttoe).

The changes in the composition of India's energy consumption was an aggregated result of changes in the mix of each sector energy consumption. The changes in the mix in turn is due to a change in the level of output, interfuel substitution, and technological improvements.

Tables 4.1 to 4.4 show the upward trend in the overall commercial energy consumption/availability in the Indian economy. The availability/consumption have increased by 33.6% in the period 1979-80 to 1984-85 and by 42.8% in 1984-85 to 1989-90 which further increased by 15.4% in the subsequent period 1989-90 to 1991-92. However, the rate of increase at its disaggregated level deviates from this average. For instance, though primary sector (comprising Sectors 1 to 7) was not a major commercial energy consumer at the national level, however the share is gradually increasing from 2.4% in 1979-80 to 2.5% in 1984-85 which further increased to 3.7% in 1989-90 and 4.3% in 1991-92. This increase in demand from agriculture sector is mainly due to the mechanization of Indian agriculture, both for land preparation and for lift irrigation. The industrial sector which includes both manufacturing and mining (Sector No. 8, 9, 10, 11) continues to be the single largest commercial energy consuming sector with the share being 54.0% in 1979-80, 53.9% in 1984-85. The respective shares in 1989-90 and 1991-92 were 47.3% and 51.0% respectively. It is clear from the above trend that the share of industrial sector is continuously declining which may be attributed to largely a relatively rapid expansion of non-energy intensive industries and the adoption of new technologies for certain industrial process alongwith the successive implementation of energy conservation measures in some industrial units.

Another important thing revealed from the above table is the fluctuating share of the transport sector from 25.2% in 1979-80 to 23.5% in 1984-85. which increased to 24.1% in 1989-90 and further declined to 22.4% in 1991-92. This is mainly due to a fall in the share of traffic handeled by the railways. For passenger transport the growth of public modes i.e buses, mini-buses have not kept pace with the rise in the more energy intensive mechanized private modes i.e cars, taxies, two-wheelers etc.

A closer examination of the tables reveal the detailed direct energy consumption pattern of the sectors at a disaggregated level.

Table 4.1. The Direct Energy Consumption of the Sectors in the Year 1979-80(E*79)

Units Ttoe.

S N O	Coal	in %	Crude oil.	in %	Petroleum	in %	Electricitin	%
8	1739.5	3.44	0	0	11.16973	0.04	133.85	1.70
9	63.90918	0.12	0	0	28.59685	0.12	19.61666	0.24
24	7.420167	0.01	27470	97.3	1.332801	0.00	66.7275	0.84
43	16336.6	32.3	440.3952	1 56	2123.458	9.36	2384.166	30.3
1	16.75521	0.03	0.076605	0.00	105.5731	0.46	895.4733	11.4
2	0	0	0	0	8.183160	0.03	59.96355	0.76
3	0	0	33.4152	0 11	5.564894	0.02	38.60484	0.49
4	0	0	0	0	17.84395	0.07	122.8456	1.56
5	0	0	0	0	0	0	4.112544	0.05
6	0	0	0	0	0	0	0	0
7	0	0	0	0	4.674856	0.02	0	0
10	19.38817	0.03	0	0	75.03020	0.33	48.775	0.62
11	110.8237	0.21	0	0	149.1832	0.65	16.37916	0.20
12	105.7972	0.20	0	0	40.38	0.17	63.81624	0.81
13	177.8446	0.35	0	0	13.59457	0.05	5.22	0.06
14	578.0549	1.14	33.27251	0.11	370.3055	1.63	140.3623	1.78
15	183.3499	0.36	25.64596	0.09	305.8309	1.34	320.6124	4.08
16	9.574409	0.01	0	0	2.709894	0.01	9.06888	0.11
17	95.50473	0.18	0.374517	0.00	12.74295	0.05	12.34008	0.15
18	146.9671	0.29	8.630935	0.03	102.2662	0.45	115.7656	1.47
19	27.04770	0.05	0	0	456.8843	2.01	6.73728	0.08
20	710.1818	1.40	0.348982	0.00	96.38820	0.42	166.7616	2.12
21	12.68609	0.02	0.008511	0.00	11.78196	0.05	6.14568	0.07
22	196.2753	0.38	0.042558	0.00	109.6095	0.48	38.48184	0.49
23	11.01057	0.02	3.694108	0.01	38.49130	0.16	12.62544	0.16
25	4310.638	8.53	0	0	97.66769	0.43	14.81784	0.18
26	1033.9	2.04	0	0	2683.176	11.8	354.6966	4.51
27	16.51585	0.03	0	0	18.85310	0.08	350.7213	4.46
28	433.4813	0.85	70.06889	0.24	189.7396	0.83	81.04224	1.03
29	309.2534	0.61	0.331959	0.00	590.2472	2.60	290.7609	3.70
30	2219.7	4.39	0	0	151.69	0.66	152.3335	1.93
31	2811.286	5.56	98.79612	0.35	282.2340	1.24	68.5212	0.87
32	11034.8	21.8	0.255353	0.00	417.488	1.84	596.0752	7.59
33	571.8316	1.13	13.22729	0.04	289.2712	1.27	306.6715	3.90
34	37.57955	0.07	6.851975	0.02	155.9910	0.68	64.25472	0.81
35	34.22851	0.06	8.741588	0.03	35.55914	0.15	47.11224	0.59
36	54.57413	0.10	0	0	37.26512	0.16	51.3648	0.65
37	23.21794	0.04	0.076605	0.00	149.3270	0.65	68.32632	0.87
38	10.77121	0.02	11.47386	0.04	52.19250	0.23	21.13056	0.26
39	0.718080	0.00	0.008511	0.00	7.890184	0.03	3.78624	0.04
40	300.8758	0.59	0.817129	0.00	136.3189	0.60	35.55168	0.45
41	6139.7	12.1	0	0	918.4	4.05	190.8333	2.43
42	33.03171	0.06	0	0	12090.64	53.3	14.95380	0.19
44	185.2648	0.36	0	0	0	0	40.72613	0.51
45	0	0	0	0	7.783560	0.03	0.919368	0.01
46	404.0400	0.79	0	0	273.0110	1.20	409.6098	5.21
Tot	50514.1	100	28226.55	100	22676.34	100	7852.661	100

Note: For the name of the Sectors see Table 3.1.

Table 4.2 The Direct Energy Consumption of the Sectors in the Year 1984-85(E^*84).

Units Ttoe.

S.N.	Coal	in %	Oil.	in %	Petroleum	in %	E'city	in %
8	2033.5	3.02	2.272386	0.00	23.12998	0.08	184.1666	1.45
9	0	0	5.817785	0.01	187.3680	0.71	49.48996	0.39
24	31.56577	0.04	35600	89.4	143.7968	0.54	52.51066	0.41
43	30482.9	45.3	1245.787	3.12	2851.52	10.8	3444.166	27.1
1	6.598020	0.00	290.7108	0.73	226.6124	0.86	1248.750	9.85
2	0	0	22.53350	0.05	12.77147	0.04	137.5383	1.08
3	0	0	53.1216	0.13	0	0	0.885156	0.00
4	0	0	49.13590	0.12	59.04244	0.22	348.3539	2.75
5	0	0	0	0	0	0	0	0
6	23.03095	0.03	0	0	1.188759	0.00	11.17529	0.08
7	0	0	12.87289	0.03	5.509890	0.02	0	0
10	0.296429	0.00	15.26425	0.03	124.2318	0.47	44.69647	0.35
11	1.110896	0.00	30.35004	0.07	148.1001	0.56	299.7627	2.36
12	20.81827	0.03	22.70007	0.05	54.754	0.20	89.0376	0.70
13	39.83681	0.05	3.033814	0.00	112.7031	0.42	8.256904	0.06
14	185.9059	0.27	82.63873	0.20	127.0961	0.48	255.2342	2.01
15	297.1178	0.44	112.7865	0.28	322.6441	1.22	551.6829	4.35
16	113.8105	0.16	0.999374	0.00	104.0086	0.39	18.54317	0.14
17	14.00445	0.02	4.699438	0.01	7.452289	0.02	14.84573	0.11
18	63.18703	0.09	37.71448	0.09	185.4278	0.70	245.1289	1.93
19	19.41066	0.02	101.9599	0.25	5.932909	0.02	11.28265	0.08
20	374.1814	0.55	21.51034	0.05	73.69537	0.28	85.64682	0.67
21	5.831356	0.00	2.629306	0.00	4.835714	0.01	11.16745	0.08
22	39.59004	0.05	24.46087	0.06	39.52530	0.15	62.10057	0.49
23	4.491804	0.00	8.589859	0.02	95.55992	0.36	24.69960	0.19
25	8530.421	12.6	21.79587	0.05	15.38928	0.05	22.13893	0.17
26	1906.1	2.83	48.30308	0.12	3926.285	14.9	423.8333	3.34
27	0.749186	0.00	0.927990	0.00	7.998475	0.03	432.8290	3.41
28	98.02640	0.14	9.339390	0.02	659.5192	2.50	262.1199	2.06
29	164.2477	0.24	29.05323	0.07	522.1722	1.98	592.5338	4.67
30	3483.9	5.17	28.22042	0.07	156.36	0.59	293.3500	2.31
31	867.0091	1.28	62.98437	0.15	116.3231	0.44	161.2684	1.27
32	11637.5	17.3	151.5360	0.38	499.73	1.90	1255.133	9.90
33	102.0902	0.15	64.55481	0.16	107.7686	0.40	573.5716	4.52
34	65.70474	0.09	34.81153	0.08	11.06170	0.04	176.6996	1.39
35	31.83843	0.04	7.935507	0.01	11.07455	0.04	71.86800	0.56
36	10.71558	0.01	8.316221	0.02	30.00643	0.11	6.917825	0.05
37	33.66629	0.05	33.32437	0.08	101.5187	0.38	111.9790	0.88
38	14.02791	0.02	11.64746	0.02	45.09250	0.17	46.72076	0.36
39	0.617711	0.00	1.760802	0.00	8.240820	0.03	9.551995	0.07
40	131.0608	0.19	30.42142	0.07	37.37947	0.14	65.56945	0.51
41	4655	6.92	133.0714	0.33	1221.235	4.64	250	1.97
42	0	0	1310.036	3.29	13409.41	51.0	16.41984	0.12
44	396.3981	0.58	0	0	349.4232	1.32	24.84510	0.19
45	0	0	1.737007	0.00	28.11990	0.10	22.19295	0.17
46	1371.138	2.03	60.92613	0.15	106.2861	0.40	647.2019	5.10
Tot	67257.4	100	39802.29	100	26287.30	100	12665.86	100

Note: For the name of the Sectors see Table 3.1.

Table 4.3 The Direct Energy Consumption of the Sectors in the Year 1989-90(E*89). Units Ttoe.

S.N.	Coal	in %	Oil.	in %	Petroleum	in %	E'city	in %
8	1945.3	2.00	54.10378	0.09	329.4270	0.85	291.6666	1.72
9	0	0	7.105996	0.01	172.3585	0.44	43.10412	0.25
24	1.937228	0.00	51900	92.4	1357.054	3.53	334.8749	1.98
43	55370	56.9	1833.552	3.26	2762.62	7.20	4438.333	26.2
1	315.8893	0.32	64.99386	0.11	275.5299	0.71	2673.259	15.8
2	0	0	4.352182	0.00	36.96509	0.09	275.5895	1.62
3	0	0	66.8304	0.11	0	0	0	0
4	116.9601	0.12	8.916195	0.01	158.1953	0.41	713.2857	4.21
5	0	0	0.298490	0.00	0	0	0	0
6	0	0	0	0	12.04887	0.03	9.190901	0.05
7	0	0	0	0	11.05074	0.02	0	0
10	1.210767	0.00	4.958791	0.00	65.17251	0.16	90.48614	0.53
11	3.329611	0.00	11.63149	0.02	112.9319	0.29	197.5955	1.16
12	88.14389	0.09	58.86037	0.10	86.79	0.22	148.0378	0.87
13	132.7001	0.13	6.451243	0.01	95.46571	0.24	14.15378	0.08
14	838.4566	0.86	72.16726	0.12	149.4111	0.38	397.7851	2.35
15	1389.840	1.43	152.0760	0.27	397.3845	1.03	682.6863	4.03
16	385.0846	0.39	1.376907	0.00	210.6908	0.54	24.46466	0.14
17	103.6417	0.10	7.452630	0.01	22.08607	0.05	31.98225	0.18
18	470.8675	0.48	41.97159	0.07	174.8435	0.45	294.8108	1.74
19	23.73104	0.02	60.71871	0.10	6.829141	0.01	14.48369	0.08
20	1077.099	1.10	60.46837	0.10	73.12082	0.19	346.2402	2.04
21	43.58764	0.04	5.401712	0.00	13.70570	0.03	16.47319	0.09
22	65.07876	0.06	15.51187	0.02	40.23186	0.10	110.2695	0.65
23	6.961914	0.00	11.70852	0.02	17.95811	0.04	28.28957	0.16
25	5995.298	6.16	7.115625	0.01	37.52866	0.09	155.8411	0.92
26	1945.3	2.00	180.3459	0.32	4143.385	10.8	425.9	2.51
27	0.847537	0.00	2.753814	0.00	16.25052	0.04	14.40272	0.08
28	260.7993	0.26	38.14899	0.06	237.4097	0.61	23.41878	0.13
29	391.5017	0.40	43.90696	0.07	948.4747	2.47	277.5837	1.64
30	4282.6	4.40	47.59476	0.08	245.235	0.63	556.0226	3.28
31	2591.285	2.66	37.26315	0.06	410.0962	1.06	197.0795	1.16
32	13901.3	14.3	93.95706	0.16	594.35	1.54	1247.833	7.38
33	115.1440	0.11	110.3162	0.19	160.9748	0.41	848.7000	5.01
34	132.8817	0.13	39.84364	0.07	91.68755	0.23	130.0108	0.76
35	45.76702	0.04	13.70167	0.02	83.30920	0.21	141.4653	0.83
36	30.63242	0.03	11.67963	0.02	22.89027	0.05	4.000932	0.02
37	3.147996	0.00	21.71276	0.03	77.21514	0.20	136.0866	0.80
38	54.42401	0.05	6.797877	0.01	33.49757	0.08	79.63428	0.47
39	1.997766	0.00	2.744185	0.00	8.892111	0.02	4.372364	0.02
40	505.3139	0.51	24.11031	0.04	109.5824	0.28	189.4380	1.12
41	2807.7	2.88	31.33185	0.05	1483.64	3.86	339.1383	2.00
42	108.7269	0.11	38.37045	0.06	22918	59.7	83.90302	0.49
44	0	0	104.5005	0.18	45.15612	0.11	282.7280	1.67
45	0	0	2.359036	0.00	6.331183	0.01	10.79865	0.06
46	1627.211	1.67	850.4760	1.51	102.2711	0.26	582.6243	3.44
Tot	97181.7	100	56159.93	100	38358.05	100	16908.04	100

Note: For the name of the Sectors see Table 3.1.

Table 4.4 The Direct Energy Consumption of the Sectors in the Year 1991-92 (E^*91). Units Ttoe.

S.N.	Coal	in %	Oil.	in %	Petroleum	in %	E'city	in %
8	1989.4	1.78	0	0	196.4596	0.42	141.1467	0.75
9	0	0	0	0	281.9404	0.60	11.83380	0.06
24	220.7929	0.19	53274.97	82.9	4291.080	9.25	44.72237	0.23
43	71834	64.3	4090.363	6.36	2600	5.60	5090.833	27.2
1	364.2372	0.32	2.785268	0.00	3515.972	7.58	4429.700	23.7
2	0.032844	0.00	0	0	191.7484	0.41	0.008930	0.00
3	0	0	92.5344	0.14	0	0	0	0
4	88.75356	0.07	0.657709	0.00	1232.278	2.65	26.95739	0.14
5	0	0	0	0	0	0	0	0
6	0	0	0	0	132.3005	0.28	2.093489	0.01
7	0	0	0	0	234.1867	0.50	0	0
10	0.716396	0.00	0	0	52.89906	0.11	12.32522	0.06
11	2.767341	0.00	0	0	118.1116	0.25	39.19699	0.20
12	86.11530	0.07	13.82904	0.02	115.956	0.25	217.2973	1.16
13	59.39951	0.05	0.024853	0.00	149.3986	0.32	16.34316	0.08
14	1142.925	1.02	365.1291	0.56	810.0178	1.74	506.9524	2.71
15	1339.586	1.19	2.267036	0 00	336.5207	0.72	758.4431	4.06
16	204.4569	0.18	0.029532	0.00	92.61189	0.19	40.01392	0.21
17	70.99581	0.06	10.80634	0.01	13.02291	0.02	56.59582	0.30
18	285.5963	0.25	3.055206	0.00	86.84448	0.18	321.7244	1.72
19	27.08526	0.02	1.547368	0.00	24.10296	0.05	16.00705	0.08
20	788.4377	0.70	12.32752	0.01	187.2534	0.40	493.3951	2.64
21	44.18343	0.03	0.001685	0.00	49.44143	0.10	22.67847	0.12
22	63.75042	0.05	0.016003	0.00	137.4433	0.29	726.5533	3.89
23	15.72587	0.01	19.48411	0.03	69.09427	0.14	49.77381	0.26
25	3796.367	3.40	194.8629	0.30	86.91836	0.18	156.9720	0.84
26	2072.7	1.85	5073.751	7.90	4130	8.91	437.75	2.34
27	0.855186	0.00	0.501902	0.00	28.67228	0.06	27.71995	0.14
28	173.5929	0.15	9.411215	0.01	124.7449	0.26	7.410974	0.03
29	408.7278	0.36	310.0733	0.48	1846.582	3.98	230.7586	1.23
30	4885.3	4.37	0.002092	0.00	289.568	0.62	574.1945	3.07
31	1210.935	1.08	161.0294	0.25	666.0008	1.43	205.3237	1.09
32	15709.4	14.0	323.5864	0.50	636.028	1.37	1091.102	5.84
33	117.1158	0.10	97.20787	0.15	571.8574	1.23	307 6925	1.64
34	164.3282	0.14	30.46708	0.04	335.2253	0.72	137.5743	0.73
35	51.97158	0.04	48.60202	0.07	341.4260	0.73	134.8340	0.72
36	17.92322	0.01	5.455251	0.00	45.22661	0.09	3.285592	0.01
37	7.159711	0.00	5.524168	0.00	224.5582	0.48	140.3396	0.75
38	60.68911	0.05	1.481961	0.00	129.5709	0.27	101.9060	0.54
39	2.838255	0.00	24.69671	0.03	36.25081	0.07	5.434642	0.02
40	455.3682	0.40	31.59240	0.04	356.6719	0.76	163.3054	0.87
41	2165.8	1.93	5.660905	0.00	1484	3.20	380	2.03
42	132.8589	0.11	0	0	19537	42.1	158.9294	0.85
44	0	0	0	0	124.9348	0.26	426.4446	2.28
45	0	0	0	0	44.75804	0.09	33.80746	0.18
46	1578.709	1.41	0	0	390.8908	0.84	924.8331	4.95
Tot	111641.6	100	64213.73	100	46349.57	100	18674.21	100

Note: For the name of the Sectors see Table 3.1.

Tables 4.1 to 4.4 show the energy flows of the four energy sectors(coal, crude oil, petroleum products, electricity) i.e how this energy is distributed among the various consuming sectors. The figures in the paranthesis indicate the percentage share of energy that is allocated to each sector for the production of goods and services. It is seen that 50514.1 Ttoe of coal was sold to the producing sectors in 1979-80 of which 16336.6 Ttoe (32.3%) went to the electricity sector(43), 110343.8 Ttoe (21.8%) went to the iron and steel(32), 6139.7 Ttoe (12.1%) to rail transport services(41), 4310.63 Ttoe (8.59%) to coaltar product(25) and another 5.56% went to other metalic mineral product(31). These were the top 5 coal consumers consuming around 80% of the total coal supply. During 1984-85, the top five coal consumer sectors were electricity(43) with 30482.9 Ttoe (45.3%), iron and steel(32) with 11637.5 Ttoe (17.3%), coal tar product(25) with 8530.4 Ttoe (12.6%), rail transport(41) with 4655 Ttoe (6.92%), and cement(30) with 3483.9 Ttoe (5.17%). Compared to 1979-80, though except cement(30) the remaining four sectors remained as the major consumers their relative shares had changed. In 1989-90 and 1991-92 also the same trend was maintained as 1984-85, the difference being a continuous increase in share of electricity and a continuous decline in the share of railway transport. This trend is simply due to the structural changes in these sectors like electricity(43), rail transport services(41) etc.

As far as the crude oil & N.Gas is concerned more than 90% of the total went to the petroleum refining i.e petroleum products sectors(24) in the three consecutive periods of 1979-80 to 1989-90. Only during 1991-92 this share has slightly declined to 82.9% because of the increase in production of N.Gas which is mainly used for non-energy purposes.

In petroleum products also we made same sort of observation. Except in 1991-92, in the remaining three periods, other transport services(42), chemicals(26, 27, 28, 29), electricity(43), and rail

transport services(42) remained the major consumers consuming more than 75% of the total supply. The respective contributions of these sectors in the three sub-periods were 53.3%, 15.4%, 9.36%, 4.05% in 1979-80, 51%, 19.41%, 10.8%, 4.64% in 1984-85 and 59.7%, 13.92%, 7.20%, 3.86% in 1989-90. However, the respective positions have changed in 1991-92. During this period though the above mentioned sectors remained major consumers, cereals(1) sector also emerged as a major one consuming around 7.58% of the total, which as mentioned earlier is due to the modernisation of agriculture.

During 1979-80 the major electricity consumer sector were electricity(43), cereals(1), chemical industries(26, 27, 28, 29), iron and steel(32), other services(46), and rail transport services(41). Over the years though the same sectors had remained as the major consumers, their relative shares changed tremendously. In 1991-92, it has been observed that over the years the share of cereal(1) had been increasing while of the chemicals gradually declined to 3.74%. Over the years, as it is seen from the tables, sectors cotton textiles(15), and cement(30) had also improved their shares.

Input coefficients for the fuel purchasing sectors indicate the role that each fuel is playing in the input structure of its users. The coefficients express the intermediate output of each energy sectors in relation to the value of the total output of the purchasing sector. In other words they are the I-O technical coefficients for the rows representing these energy sectors. These I-O coefficients, because they are related to output, indicate those sectors where energy is most important. Tables 4.17 to-4.20 in the Appendix show the input coefficients for the 46 sectors of the Indian economy for the four year studied in the analysis.

4.3. Direct and Indirect Energy Intensity.

Uptil now, our results are similar to those which could be

obtained from some of the conventional methods. However, it is here that the I-O approach gives considerable different insights by tracing further flows of fuels across sectors through all the elements of (I-A*) inverse matrix. For instance, to run a thermal power plant for a whole year, coal is required as fuel. However to produce and transport coal further coal is needed. Similarly fuel may also be needed to produce output of other sectors of the economy, used as inputs in the power plants. These indirect requirement for production change the original patterns considerably but were neglected by most conventional method. One has to be careful in interpreting the indirect requirements to avoid double counting. However, what it emphasize is that the associated energy consumption are an essential part of that sector activity. A consistent set of energy intensities including the previously mentioned four individual intensities and the total primary energy intensities(TPEI), have been calculated for the years 1979-80,1984-85, 1989-90, and 1991-92. For the non-energy sectors the units are Th. Tonnes of Oil Equivalent (Ttoe) per Lakh Rupees of output (Ttoe/Rs) and for the energy sectors it is Ttoe/Ttoe. The whole range of intensities have been classified into four groups viz; more than 0.100, 0.100 - 0.050, 0.050 - 0.001, and less than 0.001 for the sake of comparision. Table 4.5 shows the total direct and indirect energy intensities for the 46 sectors of the Indian economy in the year 1979-80.

In 1979-80 the sectors with more coal intensities were coaltar product(25),cement(30), iron and steel(32), rail transport services(41), pesticides(27), iron ore(10), other non-metalic mineral products(31). The intensity of these sectors were more than 0.100. The other manufacturing sectors with intensity in the range of 0.100 - 0.050 were rail equipments(36), other chemicals(31), paper and paper products(20), non-ferrous metals(33), fertilisers(26), construction(44), motor vehicles(37), non-electrical machinery(34), electrical machinery(35), rubber product(22), woolen textiles(17), tea and coffee(3). While the remaining manufacturing sectors viz; food products(12,13,14), textile products(15,16,17,18), wood and wood products(19), paper

Table 4.5 Total Primary Energy Intensity of 1979-80

S.No.	Coal	Crude Oil	Petroleum	Elect'ty	TPEI
8	1.044939	0.002678	0.002081	0.004016	1.049788
9	0.019529	1.005684	0.004657	0.002900	1.027256
24	0.032077	1.194237	1.006802	0.007498	1.381621
43	2.911623	0.531120	0.387894	1.398750	4.147685
1	0.023843	0.014822	0.012150	0.007752	0.044081
2	0.010905	0.005774	0.004700	0.003694	0.019096
3	0.050744	0.036010	0.028854	0.016150	0.098570
4	0.005172	0.004043	0.003340	0.001550	0.010436
5	0.006128	0.004680	0.003848	0.001496	0.012081
6	0.005272	0.005520	0.004623	0.000437	0.011692
7	0.002101	0.001810	0.001498	0.000310	0.004281
10	0.140458	0.079864	0.065393	0.044368	0 250691
11	0.032813	0.029610	0.024765	0.004376	0.068180
12	0.044360	0.021895	0.018011	0.008490	0.072896
13	0.025704	0.013394	0.011001	0.003969	0.042591
14	0.035416	0.022239	0.017949	0.007759	0.063949
15	0.032881	0.021550	0.017388	0.009711	0.061543
16	0.021337	0.010530	0.008183	0.004242	0.035063
17	0.051893	0.021606	0.017405	0.007291	0.079494
18	0.031369	0.014947	0.012053	0.006817	0.051285
19	0.017759	0.028799	0.024150	0.002058	0.051152
20	0.083835	0.021591	0.017526	0.014235	0.114649
21	0.021580	0.015975	0.013155	0.004188	0.041475
22	0.052976	0.028621	0.023427	0.009975	0.089741
23	0.026548	0.017258	0.013842	0.005090	0.048246
25	0.551185	0.023860	0.019824	0.006279	0.580938
26	0.083711	0.101028	0.084451	0.016300	0.205009
27	0.361799	0.089022	0.068164	0.159143	0.534651
28	0.048624	0.026652	0.020592	0.007824	0.081999
29	0.082559	0.047831	0.039388	0.019940	0.145547
30	0.300706	0.035882	0.029159	0.024681	0.352392
31	0.105144	0.023362	0.017608	0.005558	0.133731
32	0.292279	0.029371	0.023815	0.020200	0.334578
33	0.079042	0.023836	0.019323	0.012313	0.111483
34	0.056860	0.016337	0.013292	0.006921	0.078401
35	0.055065	0.018582	0.014864	0.008296	0.079723
36	0.085857	0.025350	0.020688	0.014026	0.120810
37	0.066822	0.026323	0.021640	0.010115	0.101084
38	0.047721	0.019339	0.015096	0.006761	0.072462
39	0.039247	0.018727	0.015380	0.005686	0.062923
40	0.027278	0.014646	0.012044	0.003554	0.045383
41	0.194154	0.036395	0.030253	0.009261	0.239392
42	0.016119	0.132357	0.111432	0.002783	0.166569
44	0.071504	0.019738	0.016152	0.005376	0.096163
45	0.004596	0.004752	0.003973	0.000551	0.010203
46	0.012651	0.009002	0.007435	0.002077	0.023735

Note: For the name of the Sector See Table 3.1.

products(20), leather and leather products(21), rubber products(22), plastic product(23), synthetic fiber and resin(28), other transport equipments(38), electronics and communication equipments(39), other manufacturing(40) were in the range group of 0.050 to 0.001. The primary sectors (Sector Nos 1 to 7), communication(45) were less intensive with intensity less than 0.010.

As far as petroleum products are concerned, the sectors with high intensity of more than 0.100 are other transport services(42). On the other hand the sectors with intensity 0.100 to 0.050 were iron ore(10), fertiliser(26), pesticides(27), where as the remaining manufacturing sectors were in the range of 0.050 to 0.010. In case of the petroleum products also the primary producing sectors (except fishing, tea and coffee), communication(45) and other services(46) were very low intensive with intensity less than 0.010.

In case of electricity also, like the petroleum products, there was only one sector namely pesticides(27) with an intensity of more than 0.100, whereas all other manufacturing sectors were in the range of 0.050 to 0.010. Similar to coal and petroleum product, electricity intensity is also less than 0.010 for primary sectors, communication(45) and other services(46).

The last column of the table reveals the total primary energy intensity(TPEI) which is calculated after due attention has been given to the secondary sources of energy. It is clear from the Table 4.5 that the sectors with high total primary energy intensities were coaltar product(25), pesticides(27), cement(30), iron and steel(32), iron ore(10), other transport(42), other chemicals(36), rail equipments(36), paper and paper products(20), non-ferrous metals(33), and motor vehicles(37). On the other hand the sectors with intensity of 0.100 to 0.050 were tea and coffee(3), construction(44), rubber and rubber products(22), synthetic fiber and resin(28), electrical machinery(35) ,woolen

textile(17), non-electrical machinery(34), sugar(12), other transport equipment(38), other minerals(11), other food and beverages(14), electronics and communication equipment(39), cotton textile(15), other textile(18), wood and wood products(19). Except fishing(7) the remaining sectors were in the intensity range of 0.05 to 0.01.

The direct and indirect energy requirement(intensity) for the year 1984-85 have been shown in the Table 4.6. As for the previous years 1979-80 here also we have analysed intensity both source wise and TPEI wise.

In 1984-85, the sectors with more coal intensity of more than 0.100 were coaltar product(25), cement(30), pesticides(27), iron & steel(32), fertiliser(26), rail transport(41), and other minerals(11). Whereas the sectors viz; synthetic fiber and resin(28), iron ore(10), construction(44), motor vehicles(37), rail equipment(36), other transport services(42), non-ferrous metals(33), non-electrical machinery(34), electronics and communication equipment(39) are having an intensity of 0.100 to 0.050, the remaining manufacturing sectors were in the range of 0.050 to 0.010. Communication(45) and other services(46) were very low intensive sectors with the intensity less than 0.010.

As far as petroleum product is concerned, there was only one sector with high intensity of more than 0.100 i.e fertiliser(26). On the other hand while other transport services(42), synthetic fiber and resin(28), iron ore(10) were having an intensity in the range of 0.100 - 0.050, pesticides(27), cement(30), rail transport(41), other minerals(11), plastic and plastic products(23), art silk(16), other chemicals(29), iron & steel(32), non-ferrous metals(33), other non-metalic mineral products(31), transport equipments(36, 37, 38), coal tar product(25), paper and paper products(20), construction(44) were in the range of 0.050 - 0.010. The remaining manufacturing sectors and primary producing sectors (except fiber crops) are very low petroleum intensive sectors with intensity less than 0.001.

Table 4.6 Total Primary Energy Intensity in 1984-85

S.No.	Coal	Crude Oil	Petroleum	Elect'ty	TPEI
8	1.040237	0.002646	0.001645	0.004047	1.044528
9	0.007391	1.009184	0.006602	0.002452	1.018071
24	0.028858	1.344072	1.017779	0.008525	1.466800
43	3.050547	0.505810	0.291165	1.345345	4.079960
1	0.022568	0.014958	0.009962	0.007296	0.041113
2	0.039879	0.016624	0.010808	0.015364	0.063151
3	0.026662	0.017718	0.009123	0.009633	0.048758
4	0.009301	0.007289	0.005108	0.002935	0.018132
5	0.008467	0.006275	0.004264	0.002426	0.016021
6	0.007127	0.003147	0.002098	0.001449	0.010997
7	0.002211	0.002089	0.000900	0.000467	0.004554
10	0.058879	0.081086	0.055164	0.024546	0.153963
11	0.107693	0.044245	0.027661	0.046543	0.171621
12	0.023375	0.013615	0.008740	0.007609	0.040584
13	0.012223	0.012798	0.009051	0.002917	0.026908
14	0.018736	0.012396	0.007846	0.005645	0.033920
15	0.041123	0.019994	0.012666	0.014289	0.067531
16	0.033098	0.027833	0.019637	0.009477	0.066188
17	0.025332	0.015025	0.009513	0.007556	0.044001
18	0.021653	0.011943	0.007770	0.007316	0.036996
19	0.019969	0.017055	0.006670	0.004081	0.039128
20	0.040509	0.017582	0.011467	0.008210	0.062150
21	0.014683	0.010658	0.007103	0.004238	0.027542
22	0.026801	0.015794	0.009837	0.008394	0.046577
23	0.033009	0.037979	0.026725	0.011325	0.077560
25	0.653165	0.019592	0.012380	0.006689	0.676336
26	0.128791	0.192172	0.142271	0.024784	0.342813
27	0.381163	0.074169	0.043980	0.164302	0.520029
28	0.076827	0.077979	0.056158	0.027922	0.170141
29	0.052690	0.027238	0.018314	0.017243	0.087940
30	0.544111	0.058655	0.037411	0.054197	0.626148
31	0.088933	0.024497	0.015167	0.015754	0.120611
32	0.203420	0.027516	0.017070	0.023653	0.241207
33	0.098968	0.027638	0.016446	0.031423	0.139696
34	0.080047	0.014636	0.008862	0.012244	0.100003
35	0.055196	0.013449	0.008430	0.009800	0.073022
36	0.088626	0.020222	0.012789	0.011742	0.114332
37	0.071774	0.019292	0.012022	0.012645	0.096816
38	0.053083	0.017365	0.010635	0.009890	0.075055
39	0.035960	0.012971	0.008407	0.006970	0.052259
40	0.047237	0.010786	0.006512	0.007427	0.061352
41	0.128629	0.046168	0.031756	0.009812	0.181258
42	0.006419	0.117901	0.083120	0.001589	0.132317
44	0.077173	0.015612	0.010050	0.009295	0.097120
45	0.009471	0.005942	0.004065	0.002413	0.016668
46	0.012833	0.007710	0.005177	0.002891	0.022074

Note: For the name of the Sector See Table 3.1.

Like petroleum products there is only one sector namely pesticides(27) with high electricity intensity of more than 0.100. where as in the range of 0.100 - 0.050 we have only cement (30) sector with intensity of 0.054. As is seen in the table other minerals(11), non-ferrous metals(33), synthetic fiber and resin(28), fertiliser(26), iron ore(10), iron & steel(32), other chemicals(29), other non-metalic mineral products(38), cotton textile(15), non electrical machinery(34), fiber crops(2), rail equipment(36), motor vehicles(37), plastic products(23) were with intensity of 0.050 - 0.010, the remaining sectors were the low intensive with intensity of less than 0.001.

Analysis of the total primary intensities shows that during 1984-85 there were 14 sectors with intensity of more than or equal to 0.100 namely, iron ore(10), other minerals(11), coaltar products(25), chemical products(26,27,28), cement(30), non-metalic mineral products(31), iron & steel(32), non-ferrous metal products(33), non-electrical machineries(34), rail equipments(36), rail transport services(41), other transport services(42). Likewise there were other 11 sectors whose intensities varied between 0.100 to 0.050, the sectors being fibre crops(2), cotton textiles(15), art silk(16), plastic and plastic products(23), other chemicals(29), electrical machineries(35), motor vehicles(37), other transport equipments(38), electronics & communication equipments(39), other manufacturings(40). On the other hand, except sector fishing(7) the remaining 16 sectors were low energy intensive sectors with the intensity of less than .010.

Results of the computation of total primary energy intensities along with the individual intensities for the third year considered i.e 1989-90 are reported in the Table 4.7. During this year, the sectors with intensity of more than 0.100 were coal tar products(25), non-ferrous metals(33), iron & steel(32), cement(30), iron ore(10), and other metalic mineral products(29). On the other hand while, rail transport services(41), paper and paper product(20), construction(44), electrical machinery(35),

Table 4.7 Total Primary Energy Intensity in 1989-90

S.No.	Coal	Crude Oil	Petroleum	Elect'ty	TPEI
8	1.041598	0.007714	0.007005	0.005506	1.051619
9	0.011682	1.006368	0.006329	0.002475	1.019455
24	0.041128	0.953417	1.037187	0.011521	1.117583
43	3.957465	0.364189	0.254299	1.333854	4.713763
1	0 038993	0.012280	0.011611	0.010792	0.055551
2	0.035059	0.015347	0.015036	0.009146	0.054633
3	0.004325	0.007287	0.003331	0.000735	0.012198
4	0.013509	0.006002	0.005914	0.003374	0.021113
5	0 009759	0.005002	0.004937	0.002372	0.015977
6	0.002311	0.003574	0.003793	0.000493	0.006458
7	0.001287	0.000976	0.001001	0.000258	0.002450
10	0.122127	0.034291	0.031227	0.039925	0.170885
11	0.059971	0.015908	0.014285	0.019192	0.082750
12	0.034010	0.016483	0.014858	0.008402	0.054496
13	0.023479	0.013313	0.013252	0.003728	0.039338
14	0.027986	0.010675	0.009787	0.005936	0.041407
15	0.052828	0.019373	0.017988	0.011762	0.077480
16	0.017523	0.010527	0.010632	0.002598	0.029986
17	0.030736	0.012837	0.012201	0.005731	0.046542
18	0.024358	0.009914	0.009430	0.005495	0.036857
19	0.008969	0.009778	0.007159	0.001812	0.020068
20	0.088634	0.016739	0.013880	0.017432	0.111719
21	0.022876	0.014577	0.014376	0.004710	0.040397
22	0.031076	0.011656	0.010871	0.007586	0.046052
23	0.033002	0.018051	0.016548	0.007768	0.055079
25	0.522949	0.024832	0.023514	0.020318	0.556025
26	0.074044	0.076555	0.078499	0.012517	0.163078
27	0.025458	0.010927	0.010386	0.005881	0.039185
28	0.034876	0.021118	0.020053	0.005215	0.059731
29	0.034467	0.017296	0.017124	0.007095	0.055673
30	0.249630	0.023074	0.019710	0.029844	0.283099
31	0.114921	0.023537	0.022756	0.012587	0.144512
32	0.309370	0.028692	0.025378	0.031795	0.349642
33	0.357769	0.067714	0.050462	0.110424	0.461345
34	0.094026	0.015335	0.013543	0.013555	0.114613
35	0.072536	0.014338	0.012221	0.016154	0.092680
36	0.026675	0.005361	0.004546	0.004194	0.033703
37	0.098645	0.016706	0.014774	0.015904	0.121385
38	0.055336	0.010128	0.009033	0.010009	0.069231
39	0.023013	0.005701	0.005094	0.004668	0.030573
40	0.059143	0.009879	0.008663	0.009956	0.072731
41	0.090231	0.030642	0.031118	0.010868	0.127427
42	0.016582	0.115564	0.125021	0.003577	0.147572
44	0.084677	0.014219	0.013076	0.010452	0.103250
45	0.008603	0.003740	0.003610	0.001757	0.013239
46	0.008673	0.005942	0.005402	0.001608	0.015677

Note: For the name of the Sector See Table 3.1.

other minerals(11), other manufacturing products(40), other transport equipments(38) and cotton textile products(15) were with intensity in the range of 0.100 - 0.050, all other sectors, except tea & coffee(3), animal husbandry(5), forestry and logging(6), fishing(7), wood and wood products(19), and communication(45) which were very low intensive, and were in the range of 0.050 - 0.001.

As far as crude oil & N.Gas and petroleum product are concerned they show almost equal trend of intensities. During this period there was only one sector i.e the other transport sector(42) which had an intensity of more than 0.100, while there were two sectors viz; fertiliser(26) and non-ferrous metals(33) which were in the range of 0.100 - 0.050. On the other hand except agricultural related sectors (1,2 ..,7), other food and beverages sectors(14), other textiles(18), wood and wood products(19), rail equipments(36), other transport equipments(38), electronics and communication equipments(39), other manufacturing(40), other services(46), and communication(45) which were very low intensive with an intensity of less than 0.001, the remaining sectors were in the range group of 0.050 - 0.001.

Like the previous years in this year also there was only one sector namely non-ferrous(33) metals with an electricity intensity of more than 0.100. While there was no sector with intensity in this range group of 0.100 -0.050 during this year, sectors with intensity in the range 0.050 -0.010 were iron ore(10), cement(30), coal tar product(25), paper and paper product(20), other minerals(11), motor vehicles(37), machineries, other non metalic mineral products(31), fertiliser(26), cotton textile(15), other transport equipments(38), rail transport services(41), cereals(1), and constructions(44). The remaining sectors were low intensive sectors.

The TPEI as for other years has been shown in the last column of the Table 4.7. In this year the sectors with high primary energy intensity were coaltar products(25), non-ferrous metal

Table 4.8 Total Primary Energy Intensity in 1991-92.

S.No.	Coal	Oil	Petroleum	Electri	TPEI
8	1.027183	0.004220	0.003405	0.002118	1.032521
9	0.008949	1.010196	0.008970	0.001255	1.020909
24	0.028009	1.219346	1.113914	0.004093	1.424988
43	4.675006	0.509989	0.228057	1.336738	5.585706
1	0.066198	0.039156	0.024125	0.016601	0.113705
2	0.014926	0.031234	0.018963	0.002310	0.049795
3	0.005657	0.011257	0.003298	0.000809	0.017658
4	0.006304	0.013723	0.008760	0.000933	0.021670
5	0.007783	0.008931	0.006176	0.001511	0.018105
6	0.001950	0.005447	0.004890	0.000347	0.008268
7	0.003471	0.011979	0.010737	0.000619	0.017321
10	0.027122	0.030216	0.026227	0.007075	0.063424
11	0.014755	0.012322	0.010514	0.003676	0.029746
12	0.032583	0.017686	0.012850	0.007588	0.054376
13	0.019080	0.024553	0.020710	0.003128	0.047769
14	0.033103	0.023632	0.016560	0.006075	0.061017
15	0.044307	0.018368	0.013720	0.008611	0.067198
16	0.021010	0.014427	0.011844	0.003028	0.038141
17	0.042482	0.015923	0.011410	0.008817	0.062619
18	0.033631	0.015060	0.010911	0.007163	0.052373
19	0.006767	0.007277	0.006310	0.001242	0.015383
20	0.102023	0.023614	0.017004	0.021244	0.134127
21	0.026189	0.016625	0.013465	0.005650	0.046489
22	0.079915	0.019813	0.013551	0.021330	0.107693
23	0.046361	0.032705	0.025811	0.008594	0.085501
25	0.397835	0.044804	0.022373	0.020016	0.451644
26	0.085943	0.193331	0.091460	0.012473	0.297169
27	0.032777	0.018427	0.014644	0.007544	0.055583
28	0.037808	0.029429	0.024271	0.004782	0.072388
29	0.025437	0.028549	0.022539	0.004574	0.058805
30	0.240754	0.025983	0.019017	0.024976	0.276563
31	0.088446	0.039141	0.029558	0.010950	0.135258
32	0.202425	0.026904	0.018364	0.015704	0.236523
33	0.096637	0.057211	0.043412	0.022823	0.166952
34	0.067107	0.017864	0.013588	0.007388	0.089140
35	0.045898	0.019292	0.014832	0.007014	0.069453
36	0.007516	0.003101	0.002415	0.000810	0.011221
37	0.069538	0.019152	0.014615	0.009710	0.093655
38	0.077375	0.022871	0.017605	0.012321	0.106397
39	0.020518	0.009892	0.007377	0.003004	0.032399
40	0.038290	0.011908	0.009153	0.004728	0.052939
41	0.089683	0.041958	0.035751	0.011170	0.140353
42	0.019411	0.118125	0.107107	0.003739	0.155529
44	0.073328	0.016587	0.012427	0.008061	0.094083
45	0.014795	0.007871	0.006478	0.003100	0.024539
46	0.008787	0.006450	0.005408	0.001662	0.016549

Note: For the name of the Sector See Table 3.1.

products(33), iron & steel(32), cement(30). In all there were 13 sectors whose TPEI was more than 0.100(Ttoe per lakh Rs). On the other hand, there were 11 sectors whose primary intensity was between 0.100 and 0.050. The low energy intensive sectors in this period were forest and logging(6), fishing(7), other services(46), animal husbandry(5), tea and coffee(3) etc.

The total primary energy intensities(TPEI) along with the individual intensities for the period 1991-92 has been shown in the Table 4.8.

As it is evident from the table as far as the TPEI were concerned, there were 12 sectors for which intensities were more than 0.100 Ttoe per Lakh Rs, where as there were other 17 sectors whose intensities were less than 0.100 but more than 0.050. During 1991-92 there was only 1 sector namely forestry and logging(6) whose TPEI was less than 0.010 while the remaining 12 sectors were in the range of 0.050 to 0.010.

A closer examination of the Table 4.8 reveals the patterns associated with the different individual components of the TPEI. During 1991-92 there were 4 sectors with coal intensity of more than 0.100 whereas the respective number of sectors for crude oil, petroleum products, and electricity were 2, 1, and 0. On the other hand, the number of sectors in the range of 0.100 to 0.050 and 0.050 to 0.010 were 10, 1, 1, 0 and 20, 32, 30,and 11 respectively. The remaining sectors were very less intensive with intensity of less than 0.010 Ttoe per Lakh Rs of output.

For further scanning of the trends in the total primary energy intensities, we calculated the percentage changes of energy intensities as follows.

$$PTE_t = \frac{100\ (TE_t - TE_{t-1})}{TE_{t-1}} \quad \ldots\ldots\ldots\ldots\ldots (4.2)$$

where TE_t is the TPEI at the time period t and TE_{t-1} is the energy intensities at the time period t-1.

Table 4.9. Change in Primary Energy Intensity over the Years.

S.No.	1979-80 to 1984-85	1984-85 to 1989-90	1989-90 to 1991-92.	1979-80 to 1991-92.
8	-0.50104	0.678920	-1.81607	-1.64477
9	-0.89410	0.135913	0.142692	-0.61779
24	6.165150	-23.8080	27.50623	3.138857
43	-1.63283	15.53451	18.49782	34.67044
1	-6.73174	35.11693	104.6853	157.9469
2	230.6968	-13.4881	-8.85528	160.7575
3	-50.5346	-74.9817	44.76317	-82.0850
4	73.74730	16.44090	2.637381	107.6487
5	32.61465	-0.27326	13.31430	49.86072
6	-5.93713	-41.2735	28.01758	-29.2834
7	6.369710	-46.1939	606.8509	304.5546
10	-38.5844	10.99115	-62.8849	-74.7002
11	151.7146	-51.7833	-64.0524	-56.3710
12	-44.3254	34.27854	-0.22085	-25.4060
13	-36.8236	46.19701	21.43008	12.15517
14	-46.9569	22.07306	47.35739	-4.58417
15	9.730437	14.73099	-13.2697	9.188862
16	88.76963	-54.6956	27.19673	8.779838
17	-44.6485	5.774997	34.54210	-21.2283
18	-27.8619	-0.37475	42.09746	2.122128
19	-23.5063	-48.7112	-23.3444	-69.9260
20	-45.7906	79.75645	20.05688	16.98927
21	-33.5937	46.67361	15.08143	12.08987
22	-48.0986	-1.12699	133.8512	20.00411
23	60.75660	-28.9850	55.23283	77.21564
25	16.42125	-17.7885	-18.7726	-22.2560
26	67.21851	-52.4292	82.22451	44.95433
27	-2.73487	-92.4646	41.84552	-89.6038
28	107.4913	-64.8932	21.19012	-11.7207
29	-39.5794	-36.6918	5.626555	-59.5966
30	77.68486	-54.7871	-2.30877	-21.5183
31	-9.81116	19.81691	-6.40385	1.141381
32	-27.9069	44.95465	-32.3527	-29.3070
33	25.30671	230.2474	-63.8118	49.75466
34	27.55192	14.60954	-22.2247	13.69708
35	-8.40585	26.92070	-25.0606	-12.8815
36	-5.36205	-70.5218	-66.7045	-90.7113
37	-4.22215	25.37690	-22.8443	-7.34899
38	3.578260	-7.75924	53.68426	46.83204
39	-16.9466	-41.4969	5.971858	-48.5096
40	35.18648	18.54771	-27.2125	16.64957
41	-24.2841	-29.6983	10.14370	-41.3710
42	-20.5629	11.52933	5.391823	-6.62747
44	0.994725	6.312079	-8.87820	-2.16290
45	63.35839	-20.5722	85.34570	140.4894
46	-6.99810	-28.9794	5.558543	-30.2781

Note: 1 The figures are in percentage terms; 2 For the name of the Sectors see Table 3.1.

Table 4.9 shows the percentage changes of TPEI for the three sub periods 1979-80 to 1984-85, 1984-85 to 1989-90, 1989-90 to 1991-92 and the whole period of 1979-80 to 1991-92. It is clear from the table that the intensity of agriculture is increasing over the years. This increase in intensity may be attributed to the increase in irrigated areas, replacement of hand pumps by diesel and electrical pumpsets, lower of water tables, increase in the number of old pumpsets and increase in the number of tractors. In other words the mechanization of agriculture is solely responsible for the increase in intensity in agriculture sector.

A similar increase in energy intensity had experienced in sectors like khandasari & boora(13), cotton textiles(15), art silk(16), other textiles(18), paper and paper products(20), leather and leather products(21), rubber products(22), plastic products(23), Fertilisers(26), non-metalic mineral products(31), non-ferrous metals(33), non-electrical machineries(34), other transport equipments(38), other manufacturing(40), and communication(45). As far as the cotton textiles sector is concerned the increase in intensities over the whole period under study was due to the replacement of handlooms by the powerlooms and mills.

The specific energy intensity in cement manufacture has witnessed a gradual decrease since mid 1980's as a result of technological improvements viz adoption of vertical roller mills, high efficiency separators, high efficiency fans, variable speed system etc. The study by the National Council of Cement and Building Materials(NCB) indicate that there is still scope to reduce the intensity in this industry.

Similarly, Indian Railways have undergone significant changes in the traction front during the last three decades. Share of steam locomotives in rolling stock of railways is declining and is getting replaced by the diesel and electric locomotives which are comparatively more energy efficient. This is the sole reason

behind the continuous decline in the energy intensities in the railways sector.

A similar decline in energy intensities had witnessed in sectors viz; iron ore(10), other ores(11), sugar(12), other food and beverages(14), woolen textiles(17), wood and wood products(19), coaltar products(25), pesticides(27), synthetic fiber and resin(28), other chemicals(29), iron & steel(32), electrical machineries(35), railways equipments(36), motor vehicles(37), electronics and communication equipments(39), construction(44), other transport services(42), and other services(46).

Tables4.10 to 4.12 depict source wise intensity changes over the whole period covered where a positive sign indicates an increase in intensity while a negative sign indicates a decline in intensity.

Table 4.10 Changes in the coal intensity

Pattern	1979-84	1984-89	1989-91	1979-91	Sector No.
I	-	-	-	-	29,39,41
II	+	-	-	-	6,11,19,25,30,36
III	+	+	-	-	35
IV	-	+	-	-	8,9,24,10,12,13, 31,32
V	-	+	+	-	14,17
VI	+	-	+	-	16,27,28,46
VII	-	-	+	+	3
VIII	+	-	-	+	2
IX	+	-	+	+	7,23,26,45
X	+	+	-	+	4,5,15,33,34,37, 40,44
XI	-	+	+	+	1,18,20,21,22,42
XII	+	+	+	+	38,43

Table 4.11 Changes of crude oil for the periods

Pattern	1979-84	1984-89	1989-91	1979-91	Sector No.
I	-	-	-	-	15,19,36
II	+	-	-	-	10,11
III	-	+	-	-	32
IV	-	-	+	-	3,17,22,27,29,37,39,40,42,43,44,46
V	+	-	+	-	30
VI	-	+	+	-	6,12
VII	-	+	-	+	8
VIII	-	-	+	+	14,20,38
IX	+	+	-	+	33
X	-	+	+	+	13,18,21,25,34,35
XI	+	-	+	+	1,2,4,5,7,9,16,23,24,26,28,31,41,45

Table 4.12 Changes of electricity intensity for the periods

Pattern	1979-84	1984-89	1989-91	1991-92	Sector No.
I	-	-	-	-	29,36
II	+	-	-	-	2,6,11,15,19,26,28,39
III	+	+	-	-	4,8,24,32,35,37
IV	-	+	-	-	9,10,12,13
V	-	-	+	-	43,3
VI	+	-	+	-	16,27,46
VII	-	+	+	-	14
VIII	+	+	-	+	25,33,34,40,44
IX	+	-	+	+	7,17,18,23,45
X	+	-	-	+	5,30,31
XI	-	-	+	+	22
XII	-	+	+	+	1,20,42
XIII	+	+	+	+	21,38,41

4.4. Intensity in Final Demand.

Since final demand is the net product of the production system, any change in the production system will ultimately result in changes in the final demand and/or vice versa. Hence change in the energy requirement is no exception. In this section primary

energy requirement of output are broken down into changes due to six final demand factors: (i) Private Consumption (PFCE), (ii) Government Consumption (GFCE), (iii) Gross Fixed Formation (GFCF), (iv) Change in Stock (CHIS), (v) Export (EXP), (vi) Import (IMP). But during analysis of results private and government consumptions are clubbed as consumption while gross fixed investment and change in stock is treated as investment. In the previous section we have analysed the TPEI of the 46 economic sectors for the four years for which the I-O tables are available. In this section by means of the tabulated sectoral outputs to final demand and the appropriate TPEI coefficients, the primary energy embodied in outputs to final demand for the whole economy is calculated. A subdivision of this kind will give further insight into the energy analysis as it illustrates the different ways in which various policies affect the individual components of final demand. The above analysis is also done for the same time periods of 1979-80, 1984-85, 1989-90, and 1991-92.

The primary energy embodied in different components of final demand for the whole economy are calculated from the following equations:

$$E_{pfce} = e\ (I-A^*)^{-1} Y_{pfce}$$

$$E_{gfce} = e\ (I-A^*)^{-1} Y_{gfce}$$

$$E_{gfcf} = e\ (I-A^*)^{-1} Y_{gfcf}$$

$$E_{chis} = e\ (I-A^*)^{-1} Y_{chis}$$

$$E_{exp} = e\ (I-A^*)^{-1} Y_{exp}$$

$$E_{imp} = e\ (I-A^*)^{-1} Y_{imp} \quad \ldots\ldots (4.3)$$

It should be noted here that while calculating the energy requirements of imports it has been assumed that the foreign

energy intensities of any products equals its domestic counterpart as the data relating to foreign energy intensity is not available for all countries from which the goods and services are imported.

Equation (4.3) measures the contribution of separate demand factors like private consumption(PFCE), government consumption(GFCE), gross fixed investment(GFCF), change in stock(CIS), export(EXP), import(IMP) to the total energy consumption of a particular year t. For instance, Eyp measures the total contribution or share of private consumption to the total energy consumed. In this section we have calculated the total energy required directly and indirectly to produce one unit of output of a sector for the final demand, while the SDA i.e the factors responsible for a change in energy consumption between the initial year and the terminal year is dealt in the next chapter.

Table 4.13 shows the percentage contribution of the components of final demand i.e. consumption, investment, export and import to the total primary energy consumption for the year 1979-80. The figures across each row in all the four tables sum to 100%.

During the period 1979-80, it is clear from the Table 4.13 that the major contribution to the energy consumption is from the private consumption which accounts for 80.12% of the total requirement. The next important source of consumption is import which accounts for 44.12%. It should be kept in mind that the energy embodied in the import has been deducted from the total energy consumed as the goods and services imported from the rest of world are produced by the energy of those exporter countries. Investment which includes both GFCF and CHIS contribute 12.05% while export as a source contributes only 9.31% of the total requirements.

A closer examination of the table reveals an interesting picture associated with the sectoral characteristics. The cereals(1), other crops(4), animal husbandry(5), forestry &

logging(6), fishing(7), sugar(12), khandasari & gur(13), other food anb beverages(14), textiles, except other textiles(15,16,17), wood and wood products(19), paper and paper products(20), leather and leather products(21), plastic products(23),synthetic fiber and resin(28), other non-metalic mineral products(31), other manufacturing(40), transport services(41,42), communication(45), and other services(46) sectors need was basically to meet consumption. Whereas the bulk of energy requirement was due to investment in the following sectors namely fiber crops(2), tea and coffee(3), rubber products(22), coaltar product(25), pesticides(27), other chemicals(29), non-ferrous metals(33), machineries except rail equipments (34, 35, 37, 38, 39) and construction(44). On the other hand for iron ore(10), and other textile(18) sectors energy requirement basically steam from the export of the products of these sectors and for the remaining sectors import plays a major role.

The results of similar computation for the second year i.e 1984-85 are reported in the Table 4.14. In this year also like the previous year the private consumption dominates as a source of energy requirement. Private consumption contributes 69.39% of the total requirement whereas the other component of consumption i.e government consumption contribute another 7.04%. Though consumption remained as the major source, their share has declined from 92.17% in 1979-80 to 76.83% in 1984-85. The investment occupies the second position in this year, the contribution being 47%. The import and export follow the suit,the contributions being 38.6% and 15.18% respectively. Hence this change in relative share of consumption, investment, import and export indicates that the Indian economy was going through a structural change with increased energy efficiency in final consumption demand and increase in investment requirement which may be due to technological improvement of the individual sectors.

In this period also consumption, though comparatively less, plays a vital role in the same sectors as it had been in the previous year of 1979-80 except forestry & logging(6), wood and

Table 4.14. TPEI of Final Demand during 1984-85(in %)

S.N.	PFCE	GFCE	GFCF	CHIS	EXP	IMP	T.F.D
8.	25.98	0	0	78.94	2.467	7.401	100
9.	0	0	0	-9.23	-100	-209.	100
24.	885.7	0	0	-28.5	142.8	900	100
43.	100	0	0	0	0	0	100
1.	97.56	0.650	0	2.098	0.627	0.940	100
2.	0	0	0	95.01	14.52	9.534	100
3.	0	0	0	0.052	99.94	0	100
4.	93.79	0.656	0	3.411	3.443	1.351	100
5.	97.87	0.158	2 086	0.455	0.278	0.870	100
6.	32.65	0	0	47.17	23.48	3.321	100
7.	98.79	0.080	0	0	2.036	0.907	100
10.	0	0	0	10.44	89.55	0	100
11.	0	-0.48	0	-8.61	-6.38	-115.	100
12.	117.0	0.591	0	-14.9	1.264	4.034	100
13.	98.9	0	0	1.056	0	0	100
14.	92.65	0.404	0	9.652	5.892	8.602	100
15.	92.30	0.629	0	-0.45	7.592	0.074	100
16.	99.5	0.012	0	2.344	1.584	2.905	100
17.	85.5	14.58	0	0.430	1.479	1.575	100
18.	68.09	0.154	0	-0.00	33.11	1.359	100
19.	16.82	9.485	40.66	32.16	1.176	0.317	100
20.	109.1	45.39	0	34.15	5.105	93.76	100
21.	59.23	1.056	0	-0.07	40.46	0.681	100
22.	18.38	0	58.06	21.00	6.695	4.141	100
23.	91.54	0.484	0	8.552	2.778	3.361	100
25.	0	0	0	100	0	0	100
26.	0	-0.00	0	-63.7	0	-163.	100
27.	85.11	1.788	0	27.92	9.528	24.35	100
28.	0	0	0	-96.3	-3.09	-199.	100
29.	117.0	0.554	0	58.70	36.72	112.9	100
30.	0	0	0	136.9	4.947	41.92	100
31.	19.50	0	1.770	17.99	64.86	3.948	100
32.	0	0	0	-302.	-25.2	-427.	100
33.	0	0	0	-45.0	-4.66	-149.	100
34.	3.745	1.521	128.6	11.02	7.605	52.58	100
35.	16.65	1.707	87.58	0.039	3.133	9.121	100
36.	0	0	86.90	17.92	1.750	6.589	100
37.	7.843	1.783	88.63	0.123	5.224	3.770	100
38.	33.64	0.057	63.62	15.59	1.787	14.70	100
39.	72.87	16.00	52.07	4.120	1.652	46.71	100
40.	8.564	46.70	31.92	10.54	19.33	17.21	100
41.	79.30	10.00	3.725	0	6.965	0	100
42.	91.34	4.579	4.305	0	8.933	9.166	100
44.	0	3.473	96.52	0	0	0	100
45.	50.36	49.63	0	0	0	0	100
46.	57.43	33.06	3.193	0	9.034	2.731	100
Total	69.39	7.044	34.79	12.20	15.18	38.62	100

Note: The import should be deducted from the total.

For the name of the Sectors see Table 3.1.

wood products(19), synthetic fiber and resin(28), and other non-metalic mineral products(33). In addition, increasing consumption demand contributed significantly to the energy requirement in other textile(18), paper and paper products(20),plastic products(27), other chemicals(29), and electronics and other communication equipments(39) sectors.

Similarly all the sectors except tea and coffee(3), other textiles(18), non-ferrous metals(33) where the contribution from investment demand had been significant in the earlier year also gained in a similar manner during this year. Besides in animal husbandry(5), wood and wood products(19), cement(30) the contribution is high due to investment demand.

Table 4.15 shows the share of final demand categories contribution to energy requirement for the year 1989-90. During this year too the consumption(both private and government) demand was important in the energy consumption/requirements. While consumption demand contributed 87.7%, investment had a share of 45.7%. The share of exports and imports were 13.87% and 47.44% respectively. Hence the individual categories shares had increased compared to that of 1984-85 level.

Rising consumption demand had almost similar impact during 1989-90 as compared to the 1984-85. The few differences were a reduction in the impacts of consumption demand on other textiles(18), Paper and Paper products(20), leather and leather products(21), plastic products(23), pesticides(27), while an increase in impact was felt in rubber products(22), and forestry and logging(6). Similarly the trend observed due to investment expansion in the first two years was also witnessed in this year(1989-90). The only difference was a significant increase in the contribution of investment demand in plastic product(23), and synthetic fiber and resin(28), while there is a decrease in contribution in non-ferrous metals(33) sector in the year 1989-90 as compared to the previous years i.e 1979-80 and 1984-85.

Table 4.15. TPEI of Final Demand in 1989-90. (in %)

S.N.	PFCE	GFCE	GFCF	CHIS	EXP	IMP	T.F.D
8.	-85.7	0	0	-114.	-14.2	-314.	100
9.	0	0	0	-8.93	0	-108.	100
24.	204.3	0	0	-15.2	58.69	147.8	100
43.	100	0	0	0	0	0	100
1.	97.99	0.147	0	1.682	0.762	0.589	100
2.	0	0	0	355.9	1402.	1658.	100
3.	0	0	0	0	100	0	100
4.	94.28	0.095	0	0.708	5.613	0.699	100
5.	90.02	0.093	11.04	0.340	0.377	1.878	100
6.	105.4	0.278	0	0.677	0	6.432	100
7.	80.94	0.008	0	0.011	19.09	0.061	100
10.	0	0	0	2.873	97.12	0	100
11.	0	0	0	-14.6	-9.00	-123.	100
12.	100.7	0	0	0.197	0.462	1.423	100
13.	99.75	0	0	0.248	0	0	100
14.	95.66	0.088	0	0.246	4.840	0.845	100
15.	93.55	0.044	0	0.122	6.466	0.186	100
16.	86.38	0	0	12.05	2.629	1.072	100
17.	99.93	0	0	1.810	1.396	3.139	100
18.	39.65	0.407	11.92	0.974	47.52	0.493	100
19.	46.89	7.042	49.60	0.023	2.260	5.830	100
20.	78.94	51.44	0	4.018	1.380	35.78	100
21.	43.24	0.003	0	0.813	56.92	0.981	100
22.	41.57	1.922	38.07	1.181	18.84	1.597	100
23.	30.50	0.015	0	61.66	14.35	6.536	100
25.	0	0	0	-22.9	-0.81	-123.	100
26.	0	-39.7	0	-141.	-0.54	-281.	100
27.	0	1.114	0	91.26	74.93	67.30	100
28.	0	0	0	168.8	4.048	72.90	100
29.	124.1	3.088	0	2.137	22.12	51.53	100
30.	0	0	0	0	0	-100	100
31.	25.65	0.001	0.484	1.333	74.98	2.460	100
32.	0	0	-49.7	-2.92	-8.19	-160.	100
33.	0	0	0	-2.59	-4.77	-107.	100
34.	1.274	4.604	178.5	6.794	12.41	103.6	100
35.	7.363	0.693	101.8	2.918	5.783	18.56	100
36.	0	0	104.6	0.835	1.197	6.722	100
37.	6.821	4.745	88.21	0.160	5.746	5.691	100
38.	29.23	0.152	80.98	24.40	9.538	44.31	100
39.	34.57	1.257	63.63	26.47	9.382	35.31	100
40.	45.25	29.33	39.93	4.066	8.388	26.97	100
41.	68.74	13.13	3.415	0	14.70	0	100
42.	101.3	4.852	2.863	0	16.08	25.16	100
44.	0	10.12	89.87	0	0	0	100
45.	82.23	20.98	0	0	5.441	8.656	100
46.	60.10	31.46	3.017	0	7.079	1.667	100
Total	79.48	8.249	41.27	4.559	13.87	47.44	100

Note: The import should be deducted from the total.

For the name of the Sectors see Table 3.1.

As far as the exports and imports are concerned, the energy requirement in tea and coffee(3), iron ore(10), other textiles(18), leather and leather products(21), other non-metalic mineral products(31), sectors was substantially caused by export, whereas the import played a dominant place in fiber crops(2), other minerals(11), coal tar(25), fertilisers(26), cement(30), iron and steel(32), non ferrous metal(33)sectors.

And finally, the Table 4.16 gives the result of the shares of the final demand categories in the total primary energy requirements during 1991-92. In this year also like the previous years the contribution was significant from consumption in cereals(1), other crops(4), animal husbandry(5), forestry(6), fishing(7), food products(12,13,14), textiles except other textiles(15,16,17), wood and wood products(19), paper and paper products(20), other chemicals(29), other non-metalic minerals(31), other manufacturing(40), and services(41,42,45,46) sectors, whereas rubber products(22), plastic products(23), pesticides(27), cement(30), iron and steel(32), machineries and transport equipment(34,35,36,37,38,39), and constructions(44) are those sectors in which investment shares a major requirement of energy.

As far as energy demand is concerned, in fiber crops(2), tea and coffee(3), iron ore(10), other textiles(18), and leather and leather products(21), export as a source of energy demand plays a crucial role. While on the other hand like the previous years, in 1991-92 also in other chemicals(11), coal tar product(25), fertiliser(28), synthetic fiber and resin(26), and non-ferrous metals(33) import was the main source of energy requirements.

In sum, energy consumption/requirements in the Indian economy during 1979-80 to 1991-92 was largely attributable to the growth in consumption which includes both private consumption and government consumption.

Table 4.16. TPEI in Final Demand in 1991-92. (in %)

S.N.	PFCE	GFCE	GFCF	CHIS	EXP	IMP	T.F.D
8.	68.96	0.753	0	451.4	7.746	428.8	100
9.	0	0	0	-13.8	0	-113.	100
24.	330.8	76.93	0	0	123.2	431.0	100
43.	35.29	64.70	0	0	0	0	100
1.	99.71	0.138	0	-0.33	0.773	0.291	100
2.	0	0	0	1.394	111.6	13.01	100
3.	0	0	0	0	100	0	100
4.	90.72	0.094	0	1.088	8.965	0.872	100
5.	96.86	0.116	3.026	0.886	0.550	1.448	100
6.	111.9	0.321	0	0.177	0	12.47	100
7.	71.73	0.007	0	0	28.35	0.093	100
10	0	0	0	0.092	99.90	0	100
11.	0	0	0	-0.20	-9.02	-109.	100
12.	99.06	0	0	0.741	0.338	0.147	100
13.	99.80	0	0	0.195	0	0	100
14.	95.74	0.074	0	1.610	4.429	1.863	100
15.	86.57	0.040	0	1.638	12.06	0.315	100
16.	91.67	0	0	4.666	6.423	2.765	100
17.	104.6	0	0	0.125	2.698	7.475	100
18.	43.65	0.788	0.48 3	0.556	56.74	2.234	100
19.	79.68	10.12	8.605	9.412	5.735	13.56	100
20.	65.66	52.75	0	7.420	0.944	26.78	100
21.	28.13	0.004	0	0.386	72.93	1.462	100
22.	28.77	1.352	44 84	0.581	26.79	2.356	100
23.	36.62	0.015	0	50.13	24.12	10.90	100
25.	0	0	0	-87.2	-2.71	-189.	100
26.	0	-7.11	0	-2.54	-0.17	-109.	100
27.	0	1.254	0	111.5	74.53	87.31	100
28.	0	0	0	-87.1	-4.92	-192.	100
29.	103.4	3.844	0	1.856	50.16	59.35	100
30.	0	0	0	103.3	0	3.373	100
31.	82.72	0.007	2.354	8.503	17.39	10.98	100
32.	0	0	296.1	8.172	32.35	236.6	100
33.	0	0	0	-22.7	-15.4	-138.	100
34.	2.752	4.949	165.5	4.640	11.99	89.92	100
35.	14.95	0.645	96.65	1.483	7.146	20.89	100
36.	0	0	90.69	16.03	1.161	7.892	100
37.	21.84	17.12	62.35	0.091	7.716	9.134	100
38.	65.37	0.198	90.07	13.22	12.88	81.75	100
39.	83.43	1.508	68.20	1.567	10.02	64.74	100
40.	23.35	29.85	19.92	1.109	71.33	45.58	100
41.	73.82	10.65	3.064	0	12.46	0	100
42.	104.6	6.481	2.704	0	13.97	27.79	100
44.	0	5.860	94.13	0	0	0	100
45.	81.36	23.14	0	0	3.646	8.151	100
46.	61.26	23.67	2.604	0	8.805	2.356	100
Total	77.40	13.14	31.09	5.429	12.14	39.21	100

Note: The import should be deducted from the total.

*For the name of the Sectors see Table 3.1.

4.5. Summary.

This chapter employed Indian Input-Output tables to analyse the energy intensities of different sectors in the Indian economy over the period 1979-80 to 1991-92 and studied the trend of the energy intensities. Here in this exercise energy intensities of any sector is defined as the direct and indirect energy requirement of energy to produce one unit of output of that sector. Further, the contribution or the requirement of primary energy of Individual final demand categories were also analysed for the four reference period of 1979-80, 1984-85, 1989-90 and 1991-92 for which the Input-Output tables were available.

The results showed that though the structure of Indian production diverted from agriculture to Industry, especially to heavy industries and services over the period 1979-80 to 1991-92, the energisation of agriculture and the increase in demand of consumer durables and electrification of more and more households had increased the share of energy in the agriculture sector and the household sectors over the years.

The results of the chapter also indicated that the sector with high energy intensities were that of the manufacturing sectors, for instance, fertiliser, cement, iron & steel, non-ferrous metals, other non-metalic mineral products, leather products, plastic and plastic products, rail transport, and other transports. On the other hand, the less energy intensive sectors were communication, other services, wood and wood products, and primary sectors(except cereals and fibre crops) .

Further, it is noticed that the relative ranking of the sectors changes when the indirect requirements are taken into account. For instance, during 1979-80 and 1991-92, the top five coal intensive sectors were: 1.coaltar product, 2. cement, 3. iron & steel, 4.rail transport services, and 5. other non metalic mineral products. But when both the direct and indirect energy

requirements were taken into account, the sectors coaltar products, pesticides, cement, iron & steel, rail transport services became the top five coal intensive sector during 1979-80 while coaltar products, cement, iron & steel, paper and paper products and non-ferrous metal products became the five high coal intensive during 1991-92.

Finally, the results of the analysis of the final demand categories showed that over the period 1979-80 to 1991-92 increases in the energy requirements in the Indian economy was due to the growth of the consumption(mainly the private consumption) demand and investment demand. However the importance of consumption as a factor of energy need had declined over the years while that of the foreign trade had increased.

In the next chapter we deal with the empirical analysis of the structural decomposition analysis(SDA) of primary energy requirements of the Indian economy.

Appendix

Table 4.17 Direct Energy Intensity in 1979-80.

S.No.	Coal	Crude oil	Petroleum	Elect	DPEI
8	0.034147	0	0.000219	0.002627	0.035395
9	0.005101	0	0.002282	0.001566	0.006169
24	0.000320	1.185772	0.000057	0.002880	1.187432
43	1.882603	0.050750	0.244703	0.274747	2.097235
1	0.000069	0.000000	0.000439	0.003731	0.001861
2	0	0	0.000265	0.001945	0.000939
3	0	0.000935	0.000155	0.001080	0.001457
4	0	0	0.000082	0.000564	0.000273
5	0	0	0	0.000028	0.000013
6	0	0	0	0	0
7	0	0	0.000290	0	0.000043
10	0.011650	0	0.045087	0.029309	0.031996
11	0.015788	0	0.021253	0.002333	0.020072
12	0.005976	0	0.002281	0.003605	0.007986
13	0.008189	0	0.000626	0.000240	0.008395
14	0.004348	0.000250	0.002785	0.001055	0.005506
15	0.002187	0.000305	0.003648	0.003824	0.004811
16	0.001096	0	0.000310	0.001038	0.001623
17	0.014736	0.000057	0.001966	0.001904	0.015970
18	0.003023	0.000177	0.002103	0.002381	0.004618
19	0.000949	0	0.016032	0.000236	0.003476
20	0.028471	0.000013	0.003864	0.006685	0.032157
21	0.000773	0.000000	0.000717	0.000374	0.001054
22	0.009962	0.000002	0.005563	0.001953	0 011706
23	0.000925	0.000310	0.003235	0.001061	0.002214
25	0.496266	0	0.011244	0.001705	0.498750
26	0.024114	0	0.062581	0.008272	0.037375
27	0.004448	0	0.005077	0.094459	0.048868
28	0.008736	0.001412	0.003823	0.001633	0.011480
29	0.011619	0.000012	0.022177	0.010925	0.020026
30	0.224379	0	0.015333	0.015398	0.233808
31	0.058292	0.002048	0.005852	0.001420	0.061879
32	0.191857	0.000004	0.007258	0.010363	0.197745
33	0.009259	0.000214	0.004684	0.004965	0.012475
34	0.000654	0.000119	0.002716	0.001118	0.001700
35	0.001477	0.000377	0.001534	0.002033	0.003025
36	0.005408	0	0.003693	0.005090	0.008317
37	0.000979	0.000003	0.006298	0.002881	0.003264
38	0.000840	0.000895	0.004073	0.001649	0.003112
39	0.000176	0.000002	0.001935	0.000928	0.000899
40	0.006179	0.000016	0.002799	0.000730	0.006956
41	0.156489	0	0.023408	0.004863	0.162267
42	0.000286	0	0.104732	0.000129	0.016141
44	0.000769	0	0	0.000169	0.000847
45	0	0	0.000614	0 000072	0.000126
46	0.000527	0	0.000356	0.000534	0.000827

Note: For the name of the Sectors see Table 3.1.

Table 4.18 Direct Energy Intensity in 1984-85.

S.No.	Coal	Crude oil	Petroleum	Elect	DPEI
8	0.028515	0.000031	0.000324	0.002582	0.029532
9	0	0.000174	0.005626	0.001486	0.001225
24	0.001169	1.319138	0.005328	0.001945	1.321503
43	2.182671	0.089202	0.204177	0.246613	2.381295
1	0.000019	0.000851	0.000663	0.003656	0.002282
2	0	0.000695	0.000394	0.004245	0.002301
3	0	0.004511	0	0.000075	0.004539
4	0	0.000178	0.000214	0.001266	0.000666
5	0	0	0	0	0
6	0.001348	0	0.000069	0.000654	0.001596
7	0	0.000751	0.000321	0	0.000780
10	0.000115	0.005955	0.048473	0.017439	0.016843
11	0.000126	0.003449	0.016832	0.034069	0.017678
12	0.000801	0.000874	0.002108	0.003429	0.003132
13	0.001207	0.000091	0.003416	0.000250	0.001696
14	0.001104	0.000491	0.000755	0.001517	0.002224
15	0.003053	0.001158	0.003315	0.005668	0.006604
16	0.003770	0.000033	0.003446	0.000614	0.004338
17	0.002646	0.000888	0.001408	0.002805	0.004697
18	0.000691	0.000413	0.002030	0.002684	0.002279
19	0.000985	0.005179	0.000301	0.000573	0.006403
20	0.009526	0.000547	0.001876	0.002180	0.011047
21	0.000306	0.000138	0.000253	0.000586	0.000684
22	0.001716	0.001060	0.001713	0.002692	0.003925
23	0.000430	0.000824	0.009167	0.002369	0.002948
25	0.548749	0.001402	0.000989	0.001424	0.550766
26	0.052582	0.001332	0.108311	0.011692	0.067893
27	0.000171	0.000211	0.001826	0.098837	0.037106
28	0.006098	0.000581	0.041032	0.016308	0.016369
29	0.001848	0.000326	0.005875	0.006667	0.005164
30	0.397329	0.003218	0.017832	0.033455	0.414512
31	0.019621	0.001425	0.002632	0.003649	0.022631
32	0.082516	0.001074	0.003543	0.008899	0.087198
33	0.002774	0.001754	0.002928	0.015587	0.010555
34	0.000832	0.000440	0.000140	0.002237	0.002113
35	0.000592	0.000147	0.000206	0.001337	0.001253
36	0.000872	0.000677	0.002443	0.000563	0.001975
37	0.000789	0.000781	0.002380	0.002625	0.002754
38	0.000613	0.000509	0.001971	0.002042	0.002054
39	0.000054	0.000155	0.000726	0.000842	0.000586
40	0.002193	0.000509	0.000625	0.001097	0.003163
41	0.086706	0.002478	0.022747	0.004656	0.092935
42	0	0.007798	0.079825	0.000097	0.014949
44	0.001355	0	0.001194	0.000084	0.001493
45	0	0.000100	0.001624	0.001282	0.000719
46	0.001630	0.000072	0.000126	0.000769	0.001999

Note: For the name of the Sectors see Table 3.1.

Table 4.19 Direct Energy Intensity in 1989-90.

S.No.	Coal	Crude oil	Petroleum	Elect	DPEI
8	0.020162	0.000560	0.003414	0.003023	0.021885
9	0	0.000185	0.004504	0.001126	0.000941
24	0.000034	0.917641	0.023994	0.005920	0.921679
43	2.852940	0.094473	0.142344	0.228685	3.023803
1	0.000687	0.000141	0.000599	0.005817	0.002470
2	0	0.000074	0.000630	0.004702	0.001415
3	0	0.004014	0	0	0.004014
4	0.000273	0.000020	0.000369	0.001665	0.000783
5	0	0.000001	0	0	0.000001
6	0	0	0.000184	0.000140	0.000056
7	0	0	0.000430	0	0.000043
10	0.000391	0.001603	0.021072	0.029257	0.012053
11	0.000232	0.000812	0.007888	0.013803	0.005585
12	0.002339	0.001562	0.002303	0.003929	0.005201
13	0.007671	0.000372	0.005518	0.000818	0.008817
14	0.004294	0.000369	0.000765	0.002037	0.005294
15	0.008743	0.000956	0.002500	0.004294	0.011117
16	0.002601	0.000009	0.001423	0.000165	0.002797
17	0.007275	0.000523	0.001550	0.002245	0.008563
18	0.002803	0.000249	0.001040	0.001754	0.003633
19	0.001071	0.002742	0.000308	0.000654	0.004022
20	0.019836	0.001113	0.001346	0.006376	0.022818
21	0.002090	0.000259	0.000657	0.000790	0.002630
22	0.001847	0.000440	0.001141	0.003129	0.003252
23	0.000714	0.001202	0.001843	0.002904	0.002890
25	0.394042	0.000467	0.002466	0.010242	0.397541
26	0.028662	0.002657	0.061049	0.006275	0.039118
27	0.000093	0.000303	0.001792	0.001589	0.001008
28	0.010881	0.001591	0.009905	0.000977	0.013727
29	0.002648	0.000297	0.006417	0.001878	0.004097
30	0.151797	0.001687	0.008692	0.019708	0.159711
31	0.050997	0.000733	0.008070	0.003878	0.053590
32	0.132469	0.000895	0.005663	0.011890	0.137163
33	0.007911	0.007579	0.011060	0.058312	0.032451
34	0.001470	0.000440	0.001014	0.001438	0.002403
35	0.000534	0.000160	0.000973	0.001652	0.001241
36	0.000967	0.000368	0.000722	0.000126	0.001442
37	0.000062	0.000432	0.001537	0.002709	0.001384
38	0.001914	0.000239	0.001178	0.002801	0.003033
39	0.000052	0.000072	0.000234	0.000115	0.000180
40	0.003534	0.000168	0.000766	0.001325	0.004139
41	0.042912	0.000478	0.022675	0.005183	0.047064
42	0.000519	0.000183	0.109474	0.000400	0.011735
44	0	0.000306	0.000132	0.000829	0.000545
45	0	0.000112	0.000301	0.000514	0.000282
46	0.001294	0.000676	0.000081	0.000463	0.002105

Note: For the name of the Sectors see Table 3.1.

Table 4.20 Direct Energy Intensity in 1991-92.

S.No.	Coal	Crude oil	Petroleum	Elect	DPEI
8	0.017709	0	0.001748	0.001256	0.018328
9	0	0	0.006536	0.000274	0.001110
24	0.004531	1.093458	0.088073	0.000917	1.112196
43	3.398182	0.193498	0.122995	0.240827	3.676853
1	0.000806	0.000006	0.007783	0.009806	0.004720
2	0.000000	0	0.005556	0.000000	0.000881
3	0	0.005866	0	0	0.005866
4	0.000240	0.000001	0.003344	0.000073	0.000792
5	0	0	0	0	0
6	0	0	0.001851	0.000029	0.000301
7	0	0	0.008550	0	0.001354
10	0.000285	0	0.021105	0.004917	0.004971
11	0.000173	0	0.007386	0.002451	0.002012
12	0.001802	0.000289	0.002427	0.004548	0.003717
13	0.005113	0.000002	0.012860	0.001406	0.007537
14	0.005360	0.001712	0.003798	0.002377	0.008323
15	0.006936	0.000011	0.001742	0.003927	0.008295
16	0.001672	0.000000	0.000757	0.000327	0.001881
17	0.005352	0.000814	0.000981	0.004267	0.007486
18	0.002754	0.000029	0.000837	0.003103	0.003763
19	0.000765	0.000043	0.000681	0.000452	0.001040
20	0.017387	0.000271	0.004129	0.010880	0.021280
21	0.001521	0.000000	0.001702	0.000781	0.002004
22	0.001153	0.000000	0.002487	0.013148	0.005134
23	0.000997	0.001236	0.004384	0.003158	0.003790
25	0.292704	0.015024	0.006701	0.012102	0.312090
26	0.033995	0.083216	0.067737	0.007179	0.129903
27	0.000106	0.000062	0.003572	0.003454	0.001677
28	0.012012	0.000651	0.008632	0.000512	0.014171
29	0.002365	0.001794	0.010688	0.001335	0.006218
30	0.145110	0.000000	0.008601	0.017055	0.151124
31	0.031163	0.004144	0.017139	0.005284	0.039464
32	0.091732	0.001889	0.003714	0.006371	0.095948
33	0.004845	0.004021	0.023658	0.012729	0.016087
34	0.001372	0.000254	0.002799	0.001148	0.002383
35	0.000518	0.000485	0.003409	0.001346	0.001911
36	0.000325	0.000099	0.000822	0.000059	0.000571
37	0.000123	0.000095	0.003867	0.002416	0.001490
38	0.002156	0.000052	0.004604	0.003621	0.003926
39	0.000063	0.000552	0.000810	0.000121	0.000777
40	0.003130	0.000217	0.002451	0.001122	0.004042
41	0.036662	0.000095	0.025121	0.006432	0.042494
42	0.000597	0	0.087843	0.000714	0.014712
44	0	0	0.000349	0.001192	0.000380
45	0	0	0.001693	0.001279	0.000617
46	0.001101	0	0.000272	0.000645	0.001321

Note: For the name of the Sectors see Table 3.1.

CHAPTER 5

STRUCTURAL DECOMPOSITION OF ENERGY USE

The development of an economy from a predominantly agrarian to modern industrialized one(like India) has necessitated a marked changes in the structure and functioning of internal economic activities. With these changes, the amount of energy required in the country which is a cumulative product of millions of decisıons- the consumer deciding what to consume, the government making budget decisions, the investors evaluating where to invest, the trade representatives negotiating tariff structure, the manager choosing a production technology etc (Lin and Polenske, 1995) also changes. These decisions affect what to consume (final demand) and how to produce(production technology), which ultimately determine the nation's aggregate demand for energy.

Input-Output analysis is a very useful framework for examining changes in the structure of an economy over time, particularly if a series of comparable tables are available for the economy of interest. Structural decomposition analysis, a method of distinguishing major shifts within an economy by means of comparative static changes in key sets of parameter, dates from the work of Chenery et al, Leontief and Carter. Recently, research in this area has reached a high level of sophistication. The sources of change in energy use measures the contribution of factors like production structure, growth of final demand and sectoral mix of final demand to the change in intensity. The change in technology is also an important source of change in energy requirement.

The question of cause bears a number of important issues. First, reducing energy intensity is a very desirable way of limiting the incremental environmental damage associated with the rapid economic growth, accompanied by large increase in fossil

fuel use. Second, determining the extent and direction of impact on aggregate energy intensity of structural, technological and other factors can inform Indian policy makers about the energy consequences of past decisions, providing a basis for future policies. Third, a deeper understanding of the sources of use change can help to improve the quality of energy demand forecasting. Energy demand forecasts that explicitly take into account important effects of structural and technological change will be more useful in policy making than those that cannot. The issues examined in this chapter should be of interest to energy and economic policy makers in India and those who seek to advice them. For energy analysts interested in quantifying factors affecting demand, the application of the methodologies used herein may be of interest.

Factors Affecting Economic Energy Intensity.

The factors affecting the energy intensity and thus the energy requirement of an economy may be classified as (a) structural change and technological change, (b) final demand change.

(a) Structural Change and Technological Change.

Apart from the actual physical energy intensity of production, structural shifts in the economy, changes in the value of product, and statistical artifacts influence such indicators. At the most aggregate level of the economy, structural change involves a shift between sectors of the economy. If the proportion of economic output from a sector with below average intensity, such as commerce were to rise then overall use would decline, in the absence of other changes. The sources of intensity decline must be sought at finer levels of structural detail in the industrial sector and other sectors. Besides the structural change within the economy shifts in the location of production between countries is also responsible for the change in

the use level. For instance importing energy intensive intermediate products, such as steel, petrochemical products and chemical fertilizer can significantly reduce the overall energy use of the economy. However, non-availability of data for foreign sector does not make it feasible to explore the impact of exports and imports of embodied energy.

(b) Effects of Changes in Final Demand.

The changing nature of final demand is of considerable importance in analysing the change in energy intensity. For example, as the demand for finished good, such as cigar, declines so will the output from the tobacco sector. The shift in demand, however, affects not only the tobacco sector, the cigar producer, but also the whole network of sectors that collectively satisfies the demand for cigar--the agricultural services sectors which supplies the seeds for the tobacco sector, the chemical and fertiliser sector which makes pesticide, and the wholesale and retail trade sector which sells the cigar.

To examine the influence of demand using input-output analysis, we can hold the technology of production say in its 1991-92 form and force this economy to satisfy the demand for products as it appeared in 1979-80, 1984-85, 1989-90, and 1991-92. Doing this, we can observe how significantly final demand for finished product influences structural change, and thereby the energy use changes which are independent of changes brought about by changes in technology. In particular, this illustrates how a sector's output would change if only the demand for products, not the process that makes them, is allowed to follow the change that happened in that particular period.

In this chapter we shall investigate the structural decomposition analysis(SDA) of energy in the Indian economy over the period 1979-80 to 1991-92. There by an attempt has been made to determine how much of the energy use changes in the Indian economy over the sub periods of 1979-80 to 1984-85, 1984-85 to

1989-90, 1989-90 to 1991-92 and over the whole period of 1979-80 to 1991-92. It can be attributed to final demand shifts, and/or to production technology change and/or to both. For this purpose we made use of the four I-O tables for the years 1979-80, 1984-85, 1989-90, and 1991-92 as supplied by the PPD of Government of India. For identifying and measuring the sources of change we used the following methodology which is basically an extension(modification) of Lin and Polenske(1995) model.

5.1. Model Structure.

The Hybrid unit's model is based on the conventional Input-Output analysis which is a linear, and intersectoral model of output determination. Once the total energy matrix is obtained from the $(I-A^*)^{-1}$ matrix as discussed in the previous chapter, the total energy requirement can be derived as given in the equation 5.1.

$$E = e\ (I-A^*)^{-1}Y^* \quad \ldots\ldots\ldots\ldots\ldots (5.1)$$

Now equation 5.1 can be used to calculate the change in energy consumption over two periods say t and o, which is the crux of this chapter.

If we define $R^* = (I-A^*)^{-1}$ and let $g = GDP_t / GDP_o$ be the expansion rate of the gross domestic product (GDP) between any two years. Then the change in the energy requirement of an economy between the two years can be due to changes in the final demand and/or due to changes in production technology. We apply the eq 5.1 to describe the change in India's energy consumption from 1979-80 to 1991-92 with three sub-periods as 1979-80 to 1984-85, 1984-85 to 1989-90, and 1989-90 to 1991-92 as

$$dE = E_t - E_o = e\ R^*_t Y^*_t - e\ R^*_o Y^*_o$$

Now the change in the energy requirement of an economy

between any two years say t and o can be decomposed into

$$\begin{aligned} dE &= E_t - E_o = e\,R^*_t Y^*_t - e\,R^*_o Y^*_o \\ &= e\,R^*_t Y^*_t - e\,R^*_o Y^*_t + e\,R^*_o Y^*_t - e\,R^*_o g\,Y^*_o \\ &\quad + e\,R^*_o g\,Y^*_o - eR^*_t Y^*_t \end{aligned}$$

$$\begin{aligned} &= e\,(R^*_t - R^*_o) Y_t + e\,R^*_o (Y^*_t - g\,Y^*_o) + e\,R^*_o (g - I)\,Y^*_o \\ &= e\,(R^*_t - R^*_o) Y^*_t - e\,(R^*_t - R^*_o) Y^*_o + e\,(R^*_t - R^*_o) Y^*_o \\ &\quad + e\,R^*_o (Y^*_t - g\,Y^*_o) + e\,R^*_o (g - I) Y^*_o \end{aligned}$$

$$\begin{aligned} \text{or, } dE &= e\,(R^*_t - R^*_o) Y^*_o + e\,R^*_o (Y^*_t - gY^*_o) + e\,R^*_o (g - I) Y^*_o \\ &\quad + e\,(R^*_t - R^*_o)(Y^*_t - Y^*_o) \qquad \text{.........................(5.2)} \end{aligned}$$

The first term on the right hand side of eq 5.2 is the effect of technical change on the energy requirement of the economy which includes both the direct effect of technical change on the energy requirement, through changing direct energy input coefficient and the indirect effect of technical change on the energy requirement through changing intermediate input coefficient. The second term is the effect of change in the structure of final demand. The third term is the effect of economic growth. The last term is the effect of interaction between technical change and change in final demand.

Components of final demand.

Since the final demand can be divided into private consumption, government consumption, investment, stock changes, exports, and imports, the effect of changes in the structure of final demand also can be further decomposed into constituent sub components of final demand.

In matrix notation the final demand can be written as

$$Y^* = Y^{*c} + Y^{*i} + Y^{*x} - Y^{*m} \qquad \text{...................(5.3)}$$

where Y^{*c}, Y^{*i}, Y^{*x} and Y^{*m} are the consumption part of final demand,

investment part of final demand, export of final demand and import of final demand respectively.

We use eq 5.3 to quantify the energy effects of final demand such that

$$dE = e\, R^*_o (Y^*_t - gY^*_o)$$

$$= e\, R_o [Y^{*c}_t + Y^{*i}_t + Y^{*x}_t - Y^{*m}_t - h(Y^{*c}_o + Y^{*i}_o + Y^{*x}_o - Y^{*m}_o)$$

$$+ h(Y^{*c}_o + Y^{*i}_o + Y^{*x}_o - Y^{*m}_o) - g(Y^{*c}_o + Y^{*i}_o + Y^{*x}_o - Y^{*m}_o)]$$

$$= e\, R_o (Y^{*c}_o - h^c Y^{*c}_o) + e\, R_o (Y^{*i}_t - h^i Y^{*i}_o)$$

$$+ e\, R_o (Y^{*x}_t - h^x Y^{*x}_o) - e\, R_o (Y^{*m}_t - h^m Y^{*m}_o)$$

$$- eR_o (g-h)(Y^{*c}_o + Y^{*i}_o + Y^{*x}_o - Y^{*m}_o) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5.4)$$

where the g is the growth rate of the economy and h is the growth rate of the individual final demands. And the $eR_o(g-h)(Y^{*c}_o + Y^{*i}_o + Y^{*x}_o - Y^{*m}_o)$ is known as the residue factor.

The interaction term of eq 5.2 also can be further decomposed into

$$e\, (R^*_t - R^*_o)(Y^*_t - Y^*_o)$$

$$= e\, (R^*_t - R^*_o)(Y^*_t - gY^*_o + gY^*_o - Y^*_o)$$

$= e\, (R^*_t - R^*_o)(g-I) Y^*_o$ Growth multiplied technical change effect

$+ e\, (R^*_t - R^*_o)(Y^*_t - gY^*_o)$ Effect of interaction between technical change and change in final demand structure.
................................(5.5)

We summarize the heierarchical structure of the estimated equations we use in our analysis in the Table 5.1.

Table 5.1 Structural Decomposition of Energy Use Change

1. Final demand shift	$e R^*_o(Y^*_t - gY^*_o)$
Source effects	
(i) Composition structure	$eR^*_o(Y^{*c}_t - h^c Y^{*c}_o)$
(ii) Investment Structure	$eR^*_o(Y^{*i}_t - h^i Y^{*i}_o)$
(ii) Export structure	$eR^*_o(Y^{*x}_t - h^x Y^{*x}_o)$
(iii) Import structure	$eR^*_o(Y^{*m}_t - h^m Y^{*m}_o)$
(iv) Residue effect	$-eR_o(g-h)(Y^{*c}_o + Y^{*i}_o + Y^{*x}_o - Y^{*m}_o)$
2. Production Technology effect	$e(R^*_t - R^*_o)Y^*_o$
3. Growth effect	$eR^*_o(g-I)Y^*_o$
4. Interaction effect	$e(R^*_t - R^*_o)(Y^*_t - Y^*_o)$
(i) growth X technical change	$e(R^*_t - R^*_o)(g-I)Y^*_o$
(ii) effect of interaction between technical change and change in final demand structure.	$e(R^*_t - R^*_o)(Y^*_t - gY^*_o)$
5. Total effect	$eR^*_o(Y^*_t - gY^*_o) + e(R^*_t - R^*_o)Y^*_o + eR^*_o(g-I)Y^*_o + e(R^*_t - R^*_o)(Y^*_t - Y^*_o) = e(R^*_t Y^*_t - R^*_o Y^*_o)$

Thus changes in energy use of an economy over a particular period are the result of four different effects: average growth of final demand, changes in the composition of final demand, changes in I-O coefficient and interaction effect of changes in final demand and technological coefficients. The sum of all the four effects gives us the total difference in energy use between initial year and the terminal year of a given period.

Lin and Polenske's(1995) original model of energy use change decomposed the change in energy use into only two sources: i.e the final demand effect which is further decomposed into level,

distribution, and mix effect and the technological effect which is given in the following equation

$$dE = e\, R^*_t Y^*_t - e\, R^*_t Y^*_o + e\, R^*_t Y^*_o - e\, R^*_o Y^*_o$$

where $R^*_t Y^*_o$ measures the amount of energy that would be consumed in the economy if the terminal year production technology were used to deliver initial year final demands.

$$\text{or, } dE = e\, R^*_t (Y^*_t - Y^*_o) + e\, (R^*_t - R^*_o) Y^*_o$$

This is obtained by taking the terminal year's technology weighted by the final demand change and the initial year's final demand by the technological change. But this is not the only reference point, an equally valid alternative way that can be used to separate energy use changes into the final demand shift and production technology change component as given in the following equation

$$dE = e\, R^*_t Y^*_t - e\, R^*_o Y^*_t + e\, R^*_o Y^*_t - e\, R^*_o Y^*_o$$

where $R^*_o Y^*_t$ measures the amount of energy that would be consumed in the economy if the initial year technology were used to deliver the terminal year final demands.

However, the above two formulations will only able to tell us how much more (or less) energy would have been required in the terminal year if the initial production technology had been used to satisfy terminal year final demand and how much less(or more) energy would be used in the initial year if the terminal year production technology had been available to deliver the initial year final demand. In fact the two formulations will not attribute energy use changes to final demand shifts and production technology changes uniquely because of the different sets of weight used in the two equations. For instance, in the first equation the final demand effect is analysed keeping initial year technology constant while the technology change is analysed keeping final demand constant at terminal year values. In the

existing literature on structural decomposition analysis most studies do not confront this problem rather use one of the two equations to study the change in energy due to the final demand shifts and technology shift. Though there are suggestions (Lin and Polenske 1995) which try to solve this problem by taking the average of the above two formulations and use that as a measure of the energy impact of final demand and technology changes, which is often confusing and difficult to interpret.

In order to overcome this problem of indexing, we prefer to use a procedure employing the same year weights for both the components as used in the methodology described above i.e we decompose the change in energy use by weighting both the technological change and final demand change effects by the initial year value which is given in the following formulation.

$$dE = e\, R^*_o (g-I) Y^*_o + e\, (R^*_t - R^*_o) Y^*_o + e\, R^*_o (Y^*_t - gY^*_o) + e\, (R^*_t - R^*_o)(Y^*_t - Y^*_o)$$

The first component of energy use change of our study measures that change in energy which is due only to the average growth of the final demand categories between year o and year t keeping technology constant. We can also decompose the final demand on energy use change into the different sources of change; namely, the change of private consumption, the change of government consumption, the change of gross investment, the change of exports, and the changes in the imports. While the former three sources refer to the changes in the domestic market the later two represents the change of demand in foreign market and change in supply to domestic economy from abroad. The first four of these effects have a positive sign, the last effect has a negative sign because imports are substitute for domestic output as another source of supply.

Changes in the composition of final demand refers to the difference between the actual sectoral final demand elements and that calculated according to the average growth rate of the

related final demand category. Thus the second component of SDA equation measures that energy use change which is due to changes in the composition of final demand between the initial year and the terminal year keeping technology constant. These effects are basically analysed in order to find out how much deviation of actual growth of sectors from average growth of a particular final demand category have caused change in energy use. This exogenous source of change can be decomposed into the same five categories as analysed in the growth effect. Analysis of this reveals above and below average growth industries, or the formation of the new key industries and the decline of the old matured industries(Forsell, 1988,p 22).

The summation of the first two effects of energy use change gives us the total final demand change effect on energy use assuming that technology remains constant.The next component gives the change in energy use that is due to change in technology only, keeping final demand constant. This effect reveals how much change in energy use of different sectors are due to the change in I-O coefficients. The state of technology is indicated by the row of the inverse matrix R*. Each row of the inverse matrix shows the direct and indirect energy required to produce one unit of worth of final demand. These effects indicate structural change in the production system under examination. The fourth component of SDA measures the differential effect of final demand due to technology change on energy use. In other words, this term measures the change in energy use that would be due to the interaction of both the final demand change and technology change. This component emerges as a residual when the same year weight are used for both the final demand change and the technological change components of total energy use change as explained earlier.

5.2. Decomposition of Energy Uses.

In this section we decompose the changes in primary energy consumption of the Indian economy into various sources of change.

As explained in the previous chapter primary energy consumption emanates from the goods and services produced for the final demand sectors. The sources of energy consumption change are analysed for the sub-periods 1979-80 to 1984-85, 1984-85 to 1989-90 and 1989-90 to 1991-92 as well as for the entire period i.e 1979-80 to 1991-92. Breakdown of sources of change for 1979-80 to 1984-85, 1984-85 to 1989-90, 1989-90 to 1991-92 and 1979-80 to 1991-92 are shown in the Tables 5.2, 5.3, 5.4, and 5.5 respectively. The tables display both in terms of amount and rate of change in percentages, the sources of energy use changes i.e (i) the changes in the composition of final demand, (ii) the change in the growth rate of the economy, (iii) the change in the technology of the economy, (iv) the interaction effect of both the final demand and the technology. Here the interaction effect is further subdivided into (a) interaction of growth and technology (b) interaction between technology and change in composition of final demand. On the other hand the sources of change for the fuel type have been analysed in the Tables 5.6, 5.7, 5.8, and 5.9. which enable us to show the total increase in energy use by fuel type with reference to the initial year of the period under study.

Table 5.2 breaks down the energy use changes for the period 1979-80 to 1984-85. During this period, India's total primary energy consumption increased by 32911.5 Ttoe or 46.37%. Final demand shifts - the increase in the level of economic activities and shift in spending mix towards more energy intensive products - were the main factors that pushed the energy use upward. All else being equal, these shifts would increase the energy consumption by 46125.84 Ttoe or 65%. This upward pressure on energy demand, however, was dampened by changes in production technology, which reduced the energy requirements per unit of goods and services. Holding all other factors constant, production technology change would decrease the energy use by 6492.4 Ttoe or by 9.15%. The contribution of the interaction effects of both the final demand and the I-O coefficients was -6721.9 Ttoe or -9.47% which indicates the contribution from technology change and final demand change would have been understated by 9.5% of the total initial year 1979-80 energy use, had this factor not been included as a

Table 5.2 Components of SDA of Primary Energy use changes during 1979-80 to 1984-85. Units Ttoe.

S.No.	Con 79	Fin Efc	(in %)	Growth	(in %)
8	447.5247	3671.908	96.97	135.8839	3.588
9	-16127.9	14347.75	150.8	-4896.99	-51.4
24	676.9945	84.58162	24.18	205.5589	58.77
43	3421.840	931.1618	49.47	1038.988	55.20
1	8945.693	1364.684	42.59	2716.221	84.77
2	41.65009	17.08414	8.787	12.64640	6.505
3	178.2627	582.3061	259.1	54.12672	24.08
4	1211.734	-101.436	-7.47	367.9244	27.12
5	1446.312	-326.189	-52.4	439.1502	70.65
6	169.2238	-145.209	147.7	51.38220	-52.2
7	57.98075	-30.4443	305.5	17.60495	-176.
10	326.7450	-137.811	92.00	99.21106	-66.2
11	-449.925	-272.242	15.90	-136.612	7.980
12	1099.057	244.5823	-148.	333.7118	-202.
13	887.9622	139.9699	-205.	269.6159	-395.
14	7017.702	-526.095	21.52	2130.816	-87.1
15	3984.474	-1825.74	633.6	1209.823	-419.
16	244.3170	445.4420	37.18	74.18307	6.193
17	364.9306	-126.570	73.73	110.8055	-64.5
18	1574.249	433.8378	197.9	477.9963	218.1
19	453.7996	-59.6917	127.1	137.7892	-293.
20	434.7642	-62.4096	38.67	132.0094	-81.8
21	570.9781	-139.368	82.35	173.3686	-102.
22	786.7796	-130.148	40.41	238.8934	-74.1
23	80.73508	66.13373	33.95	24.51395	12.58
25	418.9553	735.0376	68.52	127.2092	11.85
26	-613.255	-460.505	30.83	-186.205	12.46
27	261.5175	244.8945	79.43	79.40573	25.75
28	787.8421	-1165.73	108.3	239.2160	-22.2
29	73.97878	1491.143	168.4	22.46251	2.537
30	-291.801	581.9714	89.53	-88.6010	-13.6
31	2007.519	-646.171	280.9	609.5520	-265.
32	-209.254	-555.224	143.2	-63.5368	16.38
33	1470.296	-2259.62	118.9	446.4326	-23.4
34	3228.813	-1033.01	-125.	980.3791	119.2
35	1544.874	453.3958	63.40	469.0771	65.59
36	809.3754	-460.221	186.8	245.7542	-99.7
37	1782.012	169.8751	28.04	541.0803	89.33
38	561.3614	176.4478	46.50	170.4486	44.92
39	164.8310	195.6180	111.0	50.04839	28.42
40	1507.216	-737.938	-487.	457.6429	302.2
41	4890.188	1422.742	140.3	1484.829	146.4
42	7888.377	6378.807	119.2	2395.183	44.78
44	16997.47	1811.974	25.12	5161.019	71.56
45	72.57820	15.09363	14.15	22.03724	20.66
46	9772.470	-228.113	-12.2	2967.258	159.2
Total	70971.23	24576.53	74.67	21549.31	65.47

cont.

S.No.	Tech Eft	(in %)	Int Ift	(in %)	Tec+Fin	(in %)
8	-2.24230	-0.05	-19.0787	-0.50	-18.3979	-0.48
9	144.1998	1.516	-84.4993	-0.88	-128.283	-1.34
24	41.73773	11.93	17.88760	5.114	5.214584	1.490
43	-55.8729	-2.96	-32.1692	-1.70	-15.2043	-0.80
1	-602.201	-18.7	-274.716	-8.57	-91.8670	-2.86
2	96.08543	49.42	68.58744	35.28	39.41258	20.27
3	-90.0844	-40.0	-321.618	-143.	-294.266	-130.
4	893.6218	65.87	196.5276	14.48	-74.8067	-5.51
5	471.7096	75.89	36.84161	5.927	-106.385	-17.1
6	-10.0470	10.22	5.570651	-5.66	8.621280	-8.77
7	3.693206	-37.0	-0.81783	8.207	-1.93921	19.46
10	-126.072	84.17	14.89389	-9.94	53.17397	-35.5
11	-682.602	39.87	-620.292	36.23	-413.031	24.12
12	-487.161	294.8	-256.331	155.1	-108.412	65.62
13	-326.980	479.3	-150.824	221.0	-51.5420	75.55
14	-3295.29	134.8	-753.527	30.83	247.0383	-10.1
15	387.7067	-134.	-59.9319	20.79	-177.653	61.65
16	216.8793	18.10	461.2693	38.51	395.4172	33.01
17	-162.936	94.91	7.038942	-4.10	56.51202	-32.9
18	-438.617	-200.	-254.055	-115.	-120.875	-55.1
19	-106.671	227.2	-18.3578	39.11	14.03135	-29.8
20	-199.081	123.3	-31.8701	19.75	28.57774	-17.7
21	-191.812	113.3	-11.4218	6.749	46.81912	-27.6
22	-378.430	117.5	-52.3050	16.24	62.59950	-19.4
23	49.05189	25.18	55.07445	28.27	40.18061	20.62
25	68.79772	6.413	141.5917	13.20	120.7023	11.25
26	-412.221	27.59	-434.709	29.10	-309.544	20.72
27	-7.15217	-2.32	-8.86919	-2.87	-6.69755	-2.17
28	846.8625	-78.7	-995.928	92.59	-1253.06	116.5
29	-29.2803	-3.30	-599.076	-67.6	-590.186	-66.4
30	-226.685	-34.8	383.2741	58.96	452.1036	69.55
31	-196.961	85.63	3.592789	-1.56	63.39694	-27.5
32	58.39645	-15.0	172.6772	-44.5	154.9460	-39.9
33	372.0836	-19.5	-458.858	24.15	-571.835	30.09
34	889.6002	108.1	-14.5017	-1.76	-284.615	-34.6
35	-129.859	-18.1	-77.5417	-10.8	-38.1118	-5.32
36	-43.3991	17.61	11.49981	-4.66	24.67728	-10.0
37	-75.2393	-12.4	-30.0176	-4.95	-7.17239	-1.18
38	20.08697	5.294	12.41286	3.271	6.313763	1.664
39	-27.9333	-15.8	-41.6321	-23.6	-33.1506	-18.8
40	530.3364	350.2	-98.6262	-65.1	-259.654	-171.
41	-1187.53	-117.	-706.078	-69.6	-345.500	-34.0
42	-1622.08	-30.3	-1804.19	-33.7	-1311.67	-24.5
44	169.0782	2.344	69.36214	0.961	18.02417	0.249
45	45.98438	43.12	23.52552	22.06	9.563082	8.967
46	-683.887	-36.6	-191.688	-10.2	15.96359	0.856
Total	-6492.44	-19.7	-6721.91	-20.4	-4750.58	-14.4

cont

S.No.	Gr+Tec	(in %)	Tot.Eft	(in %)	Con.84
8	-0.68084	-0.01	3786.471	100	4233.995
9	43.78406	0.460	9510.458	100	-6617.46
24	12.67301	3.623	349.7658	100	1026.760
43	-16.9649	-0.90	1882.108	100	5303.949
1	-182.849	-5.70	3203.988	100	12149.68
2	29.17485	15.00	194.4034	100	236.0535
3	-27.3527	-12.1	224.7295	100	402.9923
4	271.3344	20.00	1356.637	100	2568.372
5	143.2273	23.04	621.5116	100	2067.823
6	-3.05062	3.103	-98.3037	100	70.92015
7	1.121384	-11.2	-9.96401	100	48.01674
10	-38.2800	25.55	-149.779	100	176.9652
11	-207.261	12.10	-1711.75	100	-2161.67
12	-147.919	89.54	-165.198	100	933.8588
13	-99.2824	145.5	-68.2186	100	819.7436
14	-1000.56	40.93	-2444.10	100	4573.597
15	117.7211	-40.8	-288.147	100	3696.326
16	65.85204	5.497	1197.773	100	1442.090
17	-49.4730	28.81	-171.662	100	193.2680
18	-133.179	-60.7	219.1618	100	1793.411
19	-32.3892	69.01	-46.9320	100	406.8675
20	-60.4479	37.46	-161.351	100	273.4126
21	-58.2409	34.41	-169.234	100	401.7434
22	-114.904	35.68	-321.990	100	464.7895
23	14.89384	7.646	194.7740	100	275.5091
25	20.88936	1.947	1072.636	100	1491.591
26	-125.164	8.379	-1493.64	100	-2106.89
27	-2.17164	-0.70	308.2788	100	569.7963
28	257.1366	-23.9	-1075.58	100	-287.742
29	-8.89053	-1.00	885.2487	100	959.2275
30	-68.8295	-10.5	649.9588	100	358.1572
31	-59.8041	26.00	-229.987	100	1777.531
32	17.73117	-4.57	-387.687	100	-596.941
33	112.9774	-5.94	-1899.96	100	-429.665
34	270.1133	32.84	822.4641	100	4051.277
35	-39.4299	-5.51	715.0712	100	2259.945
36	-13.1774	5.348	-246.366	100	563.0093
37	-22.8452	-3.77	605.6985	100	2387.710
38	6.099097	1.607	379.3963	100	940.7577
39	-8.48151	-4.81	176.1009	100	340.9320
40	161.0284	106.3	151.4144	100	1658.630
41	-360.577	-35.5	1013.955	100	5904.143
42	-492.520	-9.20	5347.715	100	13236.09
44	51.33797	0.711	7211.434	100	24208.91
45	13.96244	13.09	106.6407	100	179.2189
46	-207.651	-11.1	1863.569	100	11636.03
Total	-1971.32	-5.98	32911.50	100	103882.7

Note: For Sector name see Table 3.1.

component of energy use changes.

The sectoral details underlying changes in different factors over the period 1979-80 to 1984-85 are depicted in Table 5.2. The Table 5.2 shows that effect of technical change between 1979-80 to 1984-85 led to a decrease in energy consumption/use by 9.15%. Though change in I-O coefficients had relatively a modest impact on the energy use changes, there was a great variation when we look in detail of the 46 sectors. The requirements of energy from sectors like tea and coffee(3), food products and beverages(12, 13, 14), woolen textile(17), other textile(18), wood and wood products(19), leather and leather products(21), paper and paper products(20), rubber products(22), other chemicals(29), iron and steel(32), transport services(41, 42), had gone down due to technology change. On the other hand, change in technology increased energy requirements in sectors like fiber crops(2), other crops(4), animal husbandry(5), other minerals(11), art silk and synthetic(16), plastic and plastic products(23), fertiliser(26), synthetic fiber and resin(28), cement(30), non-electrical machineries(34), non-ferrous metals(33), and communication(45).

Effects of economic growth (or growth of final demand) as seen in the Table 5.2 were positive for all sectors except a few like crude oil & n.gas(9), other minerals(11), fertiliser(26), cement(30), and iron & steel(32). The growth effect of each sector shows, assuming that the technology and final demand composition remaining the same, how much would have the energy requirements/use of each sector increased. But in reality the average economic growth is not the same for all sectors, the impact of which is shown by the changes in the composition of final demand. Composition of final demand effects shows how much each sectors energy requirements deviated from that one calculated from the growth effects. The sum of both the effects shows the net effect of the final demand changes. While the growth effects was very high for sectors like cereals(1), other food products and beverages(14), cotton textile(14), transport services(41, 42), electricity(43), construction(44), and other services(46), the

composition of final demand had a significant effect on sectors like cereals(1), coal & lignite(8), Crude oil& N.gas(9), coal tar products(25), transport services(41, 42), electricity(43), and construction(44). On the other hand the final demand effects induced in reducing the energy use of the following sectors; animal husbandry(5), other food and beverages(14), cotton textile(15), fertiliser(26), synthetic fiber and resin(28), other non-metalic mineral products(31), iron and steel(32), non-ferrous metals(33), rail equipments(36) and other manufacturings(40).

Though the over all effects of the interaction of changes in final demand and changes in I-O coefficients on energy use was a mere -9.5% of the initial energy requirements of 1979-80, the effect was very significant in reducing energy use in some sectors like other minerals(11), food products(12,13,14), other textile(18), chemical products except pesticides(26,28,29), non-ferrous metals(33), other transport services(42), and other services(46). Whereas the sectors where the interaction caused an increase in energy requirement were fiber crops(2), other crops(4), art silk and synthetic(16), coaltar products(25), cement(30), iron and steel(32), and construction(44).

The results of the breakdown of sources of energy use changes for the sub-period 1984-85 to 1989-90 are reported in the Table 5.3. During this period Indian GDP manifested a growth rate of 45%. If there had not been any change, then India's energy use also would have increased by the same amount from 103882.7 Ttoe in 1984-85 to 150629.92 Ttoe in 1989-90. In other words, ceteris peribus, the economic growth would have increased India's energy use by 46747.2 Ttoe. However India's total primary use was 131358.5 Ttoe in 1989-90, which was 19272.4 Ttoe less compared to the proportional growth of GDP. The reason that the energy use did not grow as fast as its GDP was that the composition of final demand change reduced the requirement to a great extent. As shown in the Table 5.3, the composition of final demand change had reduced the requirements by 18124.6 Ttoe from its proportional growth. This shows that the economy's final demand moved towards an energy efficient product mix. However as compared to the

Table 5.3 Components of SDA of Primary Energy use changes during 1984-85 to 1989-90. Units Ttoe.

S.No.	Con 84	Fin Efc	(in %)	Growth	(in %)
8	4233.995	-6876.80	138.3	1911.637	-38.4
9	-6617.46	-8618.24	74.09	-2987.76	25.68
24	1026.760	5256.942	127.7	463.5795	11.26
43	5303.949	2501.234	38.59	2394.718	36.95
1	12149.68	-2444.48	-29.1	5485.548	65.49
2	236.0535	-340.068	145.4	106.5775	-45.5
3	402.9923	-482.303	127.8	181.9499	-48.2
4	2568.372	-49.5988	-2.89	1159.613	67.62
5	2067.823	56.45369	5.750	933.6168	95.10
6	70.92015	279.8146	181.8	32.02026	20.81
7	48.01674	30.92529	505.0	21.67943	354.0
10	176.9652	43.10532	27.63	79.89935	51.22
11	-2161.67	-579.063	-156.	-975.990	-264.
12	933.8588	68.04310	6.959	421.6347	43.12
13	819.7436	-1081.68	163.4	370.1120	-55.9
14	4573.597	-902.083	-37.1	2064.967	85.00
15	3696.326	2028.851	42.38	1668.881	34.86
16	1442.090	4493.392	291.4	651.1001	42.22
17	193.2680	144.6122	56.39	87.26000	34.02
18	1793.411	1847.593	69.96	809.7202	30.66
19	406.8675	-457.768	135.1	183.6996	-54.2
20	273.4126	210.6717	25.73	123.4450	15.07
21	401.7434	-129.876	-49.3	181.3861	68.95
22	464.7895	235.3886	54.11	209.8512	48.24
23	275.5091	-28.9235	239.8	124.3916	-1031
25	1491.591	-2482.81	141.6	673.4496	-38.4
26	-2106.89	2548.161	136.6	-951.258	-51.0
27	569.7963	-583.067	105.7	257.2615	-46.6
28	-287.742	1872.363	234.5	-129.915	-16.2
29	959.2275	1795.421	169.5	433.0886	40.90
30	358.1572	-530.166	146.1	161.7070	-44.5
31	1777.531	1654.110	50.18	802.5506	24.35
32	-596.941	-2750.54	59.20	-269.517	5.800
33	-429.665	-817.596	18.88	-193.992	4.480
34	4051.277	-167.576	-6.71	1829.141	73.27
35	2259.945	171.4209	8.082	1020.359	48.10
36	563.0093	466.6305	-252.	254.1972	-137.
37	2387.710	-72.3047	-3.87	1078.045	57.74
38	940.7577	32.64902	9.357	424.7496	121.7
39	340.9320	1032.049	186.8	153.9298	27.86
40	1658.630	943.4785	40.77	748.8674	32.36
41	5904.143	-2689.95	151.9	2665.705	-150.
42	13236.09	-7511.72	4023.	5976.060	-3201
44	24208.91	-8009.34	-172.	10930.25	235.9
45	179.2189	-101.916	190.3	80.91689	-151.
46	11636.03	1869.963	110.8	5253.640	311.3
Total	103882.7	-18124.6	-65.9	46902.77	170.7

cont

S.No.	Tech Eft	(in %)	Int Ift	(in %)	Tec+Fin	(in %)
8	28.74545	-0.57	-33.7095	0.678	-46.6880	0.939
9	-8.99405	0.077	-15.7741	0.135	-11.7133	0.100
24	-244.451	-5.94	-1361.94	-33.1	-1251.57	-30.4
43	823.9429	12.71	760.5627	11.73	388.5546	5.995
1	4266.596	50.94	1067.929	12.75	-858 427	-10.2
2	-31.8393	13.61	31.49367	-13.4	45.86906	-19.6
3	-302.170	80.08	225.2102	-59.6	361.6395	-95.8
4	422.2636	24.62	182.4963	10.64	-8.15449	-0.47
5	-5.65067	-0.57	-2.70553	-0.27	-0.15426	-0.01
6	-29.2712	-19.0	-128.705	-83.6	-115.489	-75.0
7	-22.1808	-362.	-24.3001	-396.	-14.2856	-233.
10	19.45052	12.47	13.51963	8.667	4.737772	3.037
11	1119.388	302.8	805.2592	217.8	299.8585	81.13
12	320.1132	32.74	167.8544	17.16	23.32419	2.385
13	378.6970	-57.2	-328.727	49.68	-499.707	75.52
14	1009.533	41.55	256.6841	10.56	-199.117	-8.19
15	544.5055	11.37	544.7127	11.37	298.8699	6.243
16	-788.760	-51.1	-2813.81	-182.	-2457.68	-159.
17	11.16122	4.352	13.39061	5.222	8.351355	3.256
18	-6.72092	-0.25	-9.95845	-0.37	-6.92397	-0.26
19	-198.190	58.50	133.5025	-39.4	222.9849	-65.8
20	218.0642	26.63	266.4797	32.55	168.0243	20.52
21	187.5082	71.27	24.04147	9.139	-60.6179	-23.0
22	-5.23813	-1.20	-5.01781	-1.15	-2.65280	-0.60
23	-79.8565	662.1	-27.6715	229.4	8.383502	-69.5
25	-265.333	15.13	321.8612	-18.3	441.6584	-25.1
26	1104.630	59.25	-837.244	-44.9	-1335.98	-71.6
27	-526.860	95.54	301.2559	-54.6	539.1320	-97.7
28	186.7253	23.38	-1130.73	-141.	-1215.03	-152.
29	-351.957	-33.2	-817.680	-77.2	-658.772	-62.2
30	-196.224	54.08	201.8685	-55.6	290.4631	-80.0
31	352.2518	10.68	486.8344	14.77	327.7936	9.945
32	-268.353	5.775	-1357.65	29.22	-1236.49	26.61
33	-989.294	22.84	-2329.15	53.79	-1882.49	43.47
34	591.8731	23.71	242.7469	9.724	-24.4822	-0.98
35	608.3932	28.68	320.8356	15.12	46.14773	2.175
36	-397.044	215.1	-508.341	275.4	-329.076	178.3
37	605.9270	32.45	255.2257	13.67	-18.3487	-0.98
38	-72.9957	-20.9	-35.4906	-10.1	-2.53331	-0.72
39	-141.476	-25.6	-492.145	-89.0	-428.269	-77.5
40	307.6380	13.29	313.8914	13.56	174.9936	7.562
41	-1753.43	99.03	7.202714	-0.40	798.8722	-45.1
42	1526.033	-817.	-177.051	94.84	-866.051	463.9
44	1528.085	32.97	184.3706	3.979	-505.555	-10.9
45	-36.8694	68.85	4.320077	-8.06	20.96653	-39.1
46	-3372.06	-199.	-2064.38	-122.	-541.905	-32.1
Total	6066.300	22.07	-7368.65	-26.8	-10107.5	-36.7

cont

S.No.	Gr+Tec	(in %)	Tot.Eft	(in %)	Con.89
8	12.97849	-0.26	-4970.12	100	-736.133
9	-4.06079	0.034	-11630.7	100	-18248.2
24	-110.369	-2.68	4114.124	100	5140.884
43	372.0080	5.740	6480.458	100	11784.40
1	1926.356	22.99	8375.590	100	20525.27
2	-14.3753	6.147	-233.836	100	2.217109
3	-136.429	36.15	-377.313	100	25.67846
4	190.6508	11.11	1714.774	100	4283.146
5	-2.55126	-0.25	981.7143	100	3049.538
6	-13.2159	-8.58	153.8581	100	224.7783
7	-10.0145	-163.	6.123735	100	54.14047
10	8.781861	5.630	155.9748	100	332.9401
11	505.4007	136.7	369.5932	100	-1792.08
12	144.5302	14.78	977.6456	100	1911.504
13	170.9807	-25.8	-661.606	100	158.1367
14	455.8015	18.76	2429.101	100	7002.699
15	245.8427	5.135	4786.951	100	8483.277
16	-356.123	-23.0	1541.920	100	2984.011
17	5.039262	1.965	256.4241	100	449.6921
18	-3.03447	-0.11	2640.634	100	4434.045
19	-89.4823	26.41	-338.756	100	68.11057
20	98.45541	12.02	818.6608	100	1092.073
21	84.65945	32.18	263.0594	100	664.8029
22	-2.36500	-0.54	434.9839	100	899.7734
23	-36.0550	298.9	-12.0599	100	263.4492
25	-119.797	6.834	-1752.84	100	-261.248
26	498.7375	26.75	1864.288	100	-242.607
27	-237.876	43.13	-551.411	100	18.38537
28	84.30600	10.55	798.4431	100	510.7005
29	-158.908	-15.0	1058.871	100	2018.099
30	-88.5946	24.41	-362.815	100	-4.65809
31	159.0407	4.825	3295.747	100	5073.279
32	-121.160	2.607	-4646.07	100	-5243.01
33	-446.663	10.31	-4330.04	100	-4759.70
34	267.2291	10.70	2496.184	100	6547.462
35	274.6879	12.95	2121.009	100	4380.955
36	-179.264	97.13	-184.558	100	378.4511
37	273.5744	14.65	1866.893	100	4254.603
38	-32.9573	-9.44	348.9122	100	1289.669
39	-63.8762	-11.5	552.3568	100	893.2888
40	138.8977	6.002	2313.875	100	3972.506
41	-791.669	44.71	-1770.48	100	4133.662
42	689.0001	-369.	-186.677	100	13049.41
44	689.9265	14.89	4633.373	100	28842.28
45	-16.6464	31.08	-53.5488	100	125.6701
46	-1522.47	-90.2	1687.159	100	13323.19
Total	2738.918	9.968	27475.77	100	131358.5

Note: For Sector name see table 3.1.

previous period, 1979-80 to 1984-85, where the technology effect was negative, during this period both the final demand effect and technology effect were positive. They caused the energy use to increase by 6066.3 & 28778.1 Ttoe respectively which constitutes 22.8% and 104.7% of the total energy use changes. However this increase in final demand changes and technology changes was offset by a negative interaction effects of -7368.65 Ttoe which constitutes 26.8% of the total change during this period.

In this period i.e. from 1984-85 to 1989-90, the average growth effect of almost all sectors except crude oil & N.gas(9), other minerals(11), fertiliser(26), synthetic fiber and resin(28), iron and steel(32), and other non-ferrous metal(33) were positive. Shifts in the composition of final demand had resulted in a reduction of the energy requirements i.e it had a negative effect on the total energy change. But if we look at a disaggregated level it is clear from the table that the agriculture sectors(1,2,3,4), coal & lignite(8), crude oil & N.Gas(9), other minerals(11), khandsari and gur(13), other food and beverage products(14), wood and wood products(19), leather & leather products(21), plastic and plastic products(23), coaltar products(25), synthetic fiber and resin(28), cement(30), iron and steel(32), non-ferrous metals(33), non-electrical machinery(34), motor vehicles(37), services sectors(41,42,44,45) had experienced a negative impact on the energy requirement. In other words the change in the composition of final demand helped in reducing the energy requirement in the above mentioned sectors. Whereas the sectors like animal husbandry(5), forest and logging(6), fishing(7), iron ore(10), sugar(12), textiles products (15,16,17,18), paper and paper products(20), rubber products(22), chemical products except pesticides(26,28,29), other non-metalic mineral products(31), electrical machineries(35), equipments except motor vehicles(36,38,39) , other manufacturings(40), and other services(46). had a positive contribution due to the changes in composition of final demand.

As far as technical change is concerned, the sectors which showed a negative contribution to the total energy use change

during 1984-85 to 1989-90 in order of importance were other services(46), rail transport services(41), non-ferrous metals(33), woolen textile(16), pesticides(27), rail equipments(36), other chemicals(29), tea and coffee(3), iron and steel(32), coaltar products(25), petroleum products(24), wood and wood products(19), cement(30), electronics & communication equipments(39). On the other hand changes in the I-O coefficients over the same period increased the energy requirements sizeably in sectors like cereals(1), other transports(42), construction(44), fertiliser(26), other food and beverages(14), other minerals(11), electricity(43), electrical machinery(35), motor vehicles(37), non-electrical machinery(34), cotton textile(15), other crops(4).

Like 1979-80 to 1984-85, during 1984-85 to 1989-90 also, the interaction effects between the final demand and technology helped in reducing the energy use. Over the period the most important sectors which had a negative effect of reducing the energy requirements were woolen textile(16), non-ferrous metals(33), other services(46), petroleum products(24), iron and steel(32), fertiliser(26), other chemicals(29), rail equipments(36), electronics & communication equipments(39), khandsari & gur(13), and other transports(42). On the other hand the sectors which had significant positive contributions were cereals(1), other minerals(11), cotton textiles(15), non-metalic mineral products(31), coaltar products(25), electrical machineries(35), other manufacturings(40), pesticides(27).

Table 5.4 presents the results of the computation of energy use for the third sub period 1989-90 to 1991-92.During this period the energy use manifested a growth which was higher than the second sub-period(1984-85 to 1989-90). The technological change and the final demand shifts- shifts towards more energy intensive technology and products- were the main factors that pushed the energy use upward. These two factors were responsible for 83.9% and 28.9% (9% due to composition of final demand and the remaining 19.9% was due to growth effects) of the total change in energy requirements. In contrast to this, the contribution of these factors during 1984-85 to 1989-90 were 22% and 104.7% (the

Table 5.4 Components of SDA of Primary Energy use changes during 1989-90 to 1991-92. Units Ttoe.

S.No.	Con 89	Fin Efc	(in %)	Growth	(in %)
8	-736.133	1512.247	103.9	-44.3960	-3.05
9	-18248.2	-2141.32	65.43	-1100.54	33.62
24	5140.884	-3003.42	148.6	310.0455	-15.3
43	11784.40	-876.973	-44.2	710.7149	35.84
1	20525.27	-483.227	-2.09	1237.874	5.374
2	2.217109	202.3465	109.7	0.133713	0.072
3	25.67846	24.12601	49.57	1.548662	3.182
4	4283.146	-691.487	208.5	258.3155	-77.8
5	3049.538	-379.753	-206.	183.9169	99.89
6	224.7783	10.51152	11.20	13.55632	14.45
7	54.14047	1.278593	0.354	3.265199	0.905
10	332.9401	-108.089	44.65	20.07954	-8.29
11	-1792.08	-900.895	-114.	-108.080	-13.7
12	1911.504	393.6419	78.16	115.2823	22.89
13	158.1367	-34.3223	-905.	9.537191	251.4
14	7002.699	-217.514	-6.01	422.3311	11.67
15	8483.277	827.3243	2326.	511.6245	1438.
16	2984.011	-568.042	-178.	179.9650	56.60
17	449.6921	-57.6471	-50.4	27.12083	23.73
18	4434.045	-2139.27	269.6	267.4162	-33.7
19	68.11057	-11.3170	52.81	4.107733	-19.1
20	1092.073	315.6352	46.61	65.86270	9.727
21	664.8029	216.0798	54.69	40.09411	10.14
22	899.7734	390.3864	17.39	54.26513	2.418
23	263.4492	21.83837	10.70	15.88856	7.785
25	-261.248	49.32602	64.63	-15.7558	-20.6
26	-242.607	-438.718	42.77	-14.6316	1.426
27	18.38537	-3.64358	-88.9	1.108817	27.05
28	510.7005	-1147.72	92.15	30.80023	-2.47
29	2018.099	-127.644	-118.	121.7110	113.4
30	-4.65809	274.5604	102.4	-0.28092	-0.10
31	5073.279	-3674.62	105.6	305.9683	-8.79
32	-5243.01	6841.784	111.9	-316.204	-5.17
33	-4759.70	3117.549	76.75	-287.056	-7.06
34	6547.462	1748.525	825.2	394.8759	186.3
35	4380.955	529.6986	-105.	264.2144	-52.5
36	378.4511	157.1273	-81.6	22.82430	-11.8
37	4254.603	297.4833	-54.6	256.5941	-47.1
38	1289.669	-152.583	-26.4	77.77970	13.47
39	893.2888	60.34148	34.60	53.87404	30.89
40	3972.506	281.7773	-40.1	239.5809	-34.1
41	4133.662	-1045.19	228.5	249.3002	-54.5
42	13049.41	2122.639	56.30	787.0071	20.87
44	28842.28	1633.523	318.5	1739.471	339.1
45	125.6701	30.48906	17.14	7.579136	4.262
46	13323.19	731.2328	30.97	803.5191	34.03
Total	131358.5	3588.055	9.009	7922.201	19.89

cont

S.No.	Tech Eft	(in %)	Int Ift	(in %)	Tec+Fin	(in %)
8	13.36874	0.919	-26.6572	-1.83	-27.4635	-1.88
9	-26.0389	0.795	-4.62591	0.141	-3.05550	0.093
24	1414.063	-69.9	-740.846	36.67	-826.128	40.89
43	2179.858	109.9	-30.7541	-1.55	-162.220	-8.18
1	21486.95	93.29	790.0050	3.430	-505.868	-2.19
2	-0.19633	-0.10	-17.9302	-9.72	-17.9183	-9.71
3	11.49449	23.62	11.49280	23.61	10.79957	22.19
4	112.9629	-34.0	-11.4244	3.444	-18.2371	5.499
5	406.0246	220.5	-26.0743	-14.1	-50.5615	-27.4
6	62.97747	67.14	6.743232	7.189	2.945075	3.140
7	328.5519	91.09	27.57405	7.645	7.759156	2.151
10	-209.369	86.50	55.34517	-22.8	67.97218	-28 0
11	1147.871	146.1	646.2731	82.31	577.0452	73.49
12	-4.22168	-0.83	-1.12399	-0.22	-0.86938	-0.17
13	33.88883	893.6	-5.31148	-140.	-7.35531	-193.
14	3316.296	91.65	96.99588	2.680	-103.009	-2.84
15	-1125.71	-3165	-177.675	-499.	-109.784	-308.
16	811.5538	255.2	-105.544	-33.1	-154.489	-48.5
17	155.3331	135.9	-10.5444	-9.22	-19.9125	-17.4
18	1866.620	-235.	-788.002	99.34	-900.578	113.5
19	-15.9000	74.20	1.682981	-7.85	2.641909	-12.3
20	219.0359	32.35	76.51660	11.30	63.30659	9.350
21	100.2618	25.37	38.63471	9.779	32.58794	8.248
22	1204.358	53.66	595.1717	26.52	522.5372	23.28
23	145.5104	71.30	20.83765	10.21	12.06195	5.910
25	49.04342	64.26	-6.30202	-8.25	-9.25982	-12.1
26	-199.483	19.45	-372.764	36.34	-360.733	35.17
27	7.693457	187.7	-1.06068	-25.8	-1.52467	-37.2
28	108.2180	-8.68	-236.677	19.00	-243.204	19.52
29	113.5494	105.8	-0.33383	-0.31	-7.18197	-6.69
30	0.107544	0.040	-6.33249	-2.36	-6.33897	-2.36
31	-324.885	9.341	215.7236	-6.20	235.3174	-6.76
32	1696.258	27.75	-2111.20	-34.5	-2213.50	-36.2
33	3037.256	74.78	-1806.18	-44.4	-1989.36	-48.9
34	-1455.15	-686.	-476.365	-224.	-388.605	-183.
35	-1097.89	218.2	-198.959	39.55	-132.745	26.39
36	-252.444	131.1	-120.035	62.34	-104.811	54.43
37	-971.938	178.5	-126.575	23.24	-67.9582	12.48
38	692.3498	119.9	-40.1577	-6.95	-81.9132	-14.1
39	53.34594	30.59	6.820789	3.911	3.603508	2.066
40	-1081.01	154.0	-141.874	20.22	-76.6787	10.93
41	419.3063	-91.6	-80.7335	17.65	-106.021	23.18
42	703.6013	18.66	156.8830	4.161	114.4489	3.035
44	-2560.67	-499.	-299.461	-58.3	-145.027	-28.2
45	107.2540	60.31	32.48957	18.27	26.02110	14.63
46	740.5758	31.37	85.30985	3.613	40.64589	1.721
Total	33420.61	83.92	-5107.04	-12.8	-7122.63	-17.8

cont

S.No.	Gr+Tec	(in %)	Tot.Eft	(in %)	Con.91
8	0.806266	0.055	1454.562	100	718.4286
9	-1.57040	0.047	-3272.53	100	-21520.7
24	85.28185	-4.22	-2020.15	100	3120.725
43	131.4667	6.630	1982.846	100	13767.25
1	1295.873	5.626	23031.61	100	43556.88
2	-0.01184	-0.00	184.3536	100	186.5708
3	0.693230	1.424	48.66197	100	74.34044
4	6.812768	-2.05	-331.633	100	3951.512
5	24.48725	13.30	184.1133	100	3233.651
6	3.798156	4.049	93.78855	100	318.5668
7	19.81489	5.493	360.6698	100	414.8103
10	-12.6270	5.217	-242.034	100	90.90583
11	69.22788	8.816	785.1693	100	-1006.91
12	-0.25460	-0.05	503.5786	100	2415.083
13	2.043827	53.89	3.792154	100	161.9289
14	200.0050	5.527	3618.108	100	10620.80
15	-67.8914	-190.	35.56164	100	8518.839
16	48.94462	15.39	317.9318	100	3301.943
17	9.368106	8.198	114.2623	100	563.9545
18	112.5754	-14.1	-793.235	100	3640.810
19	-0.95892	4.475	-21.4264	100	46.68417
20	13.21000	1.951	677.0504	100	1769.123
21	6.046768	1.530	395.0705	100	1059.873
22	72.63456	3.236	2244.181	100	3143.954
23	8.775703	4.300	204.0750	100	467.5243
25	2.957797	3.875	76.31156	100	-184.937
26	-12.0307	1.173	-1025.59	100	-1268.20
27	0.463990	11.32	4.098007	100	22.48338
28	6.526607	-0.52	-1245.38	100	-734.683
29	6.848141	6.383	107.2823	100	2125.381
30	0.006486	0.002	268.0545	100	263.3964
31	-19.5937	0.563	-3477.81	100	1595.463
32	102.3009	1.674	6110.634	100	867.6212
33	183.1762	4.509	4061.559	100	-698.146
34	-87.7601	-41.4	211.8809	100	6759.342
35	-66.2138	13.16	-502.941	100	3878.013
36	-15.2248	7.907	-192.528	100	185.9228
37	-58.6173	10.76	-544.436	100	3710.167
38	41.75546	7.231	577.3885	100	1867.058
39	3.217281	1.844	174.3822	100	1067.671
40	-65.1959	9.293	-701.535	100	3270.971
41	25.28826	-5.52	-457.326	100	3676.336
42	42.43403	1.125	3770.130	100	16819.54
44	-154.433	-30.1	512.8558	100	29355.13
45	6.468467	3.637	177.8118	100	303.4819
46	44.66395	1.892	2360.637	100	15683.83
Total	2015.589	5.061	39823.82	100	171182.3

Note: For the name of the sectors refer to Table 3.1

respective contribution of composition and growth were -65.9% and 170.7%). Hence while in the previous period the composition of final demand change had caused an increase in energy requirement, in this period it helped in reducing the same. All else being equal, these shifts would increase the energy consumption by 33420.61 Ttoe and 11510.25 Ttoe. On the other hand, the decrease in energy use due to both changes in composition of final demand and the changes in technology i.e the interaction effects was 5107 Ttoe or by 12.8% of the total change. If we further subdivide the interaction effects into the interaction effect between growth and technology change and change in technology and composition of final demand then the respective contributions were -17.8% and 5.06% respectively. However compared to the two previous periods the impact of interaction effects was very less during the period under study.

In the period 1989-90 to 1991-92, we see from the Table 5.4 that while at the aggregated level the growth effect has a positive contribution to the energy use changes, at a disaggregated level the sectors like other minerals(11), coaltar products(25), fertiliser(26), cement(30), iron and steel(32), and non-ferrous metals basically helped in reducing the energy use. In other words the above sectors had a negative impact on the energy use changes.

Shifts in the composition of final demand in the period 1989-90 to 1991-92 resulted in an increase in energy use of sectors like coal & lignite(8), cash crops(2), tea and coffee(3), forest and logging(6), fishing(7), sugar(12), cotton textiles(15), paper and paper products(20), leather and leather products(21), rubber products(22), plastic products(23), petroleum products(24), coaltar products(25), cement(30), iron and steel(32), non-ferrous metals(33), non-electrical machineries(34), electrical machineries(35), rail equipments(36), motor vehicles(37), electronics & communication equipments(39), other manufacturings(40), services except rail transport(42,44,45,46). The sectors with negative contribution were crude oil(9), petroleum products(24), electricity(43), cereals(1), other

Table 5.5 Components of SDA of Primary Energy use Changes during 1979-80 to 1991-92. Units ttoe.

S.No.	Con 79	Fin Efc	(in %)	Growth	(in %)
8	447.5247	-167.444	-61.8	450.3627	166.2
9	-16127.9	10703.55	-198.	-16230.1	300.9
24	676.9945	1667.468	68.23	681.2876	27.87
43	3421.840	3357.540	32.45	3443.539	33.28
1	8945.693	-1062.13	-3.06	9002.421	26.01
2	41.65009	-12.0147	-8.29	41.91421	28.92
3	178.2627	57.30667	-55.1	179.3932	-172.
4	1211.734	-528.174	-19.2	1219.419	44.50
5	1446.312	-744.024	-41.6	1455.483	81.43
6	169.2238	110.9630	74.30	170.2970	114.0
7	57.98075	-13.7941	-3.86	58.34843	16.35
10	326.7450	-296.246	125.6	328.8170	-139.
11	-449.925	-1405.19	252.2	-452.778	81.29
12	1099.057	1032.555	78.46	1106.027	84.04
13	887.9622	-1637.17	225.4	893.5932	-123.
14	7017.702	-2948.83	-81.8	7062.205	196.0
15	3984.474	-192.285	-4.24	4009.741	88.43
16	244.3170	2545.253	83.24	245.8663	8.041
17	364.9306	-16.2397	-8.15	367.2448	184.5
18	1574.249	406.6715	19.67	1584.232	76.66
19	453.7996	-755.245	185.5	456.6773	-112.
20	434.7642	639.9248	47.95	437.5212	32.78
21	570.9781	-200.020	-40.9	574.5990	117.5
22	786.7796	1041.324	44.17	791.7689	33.58
23	80.73508	101.8344	26.32	81.24705	21.00
25	418.9553	-1078.44	178.5	421.6121	-69.8
26	-613.255	355.5002	-54.2	-617.144	94.22
27	261.5175	-308.427	129.0	263.1759	-110.
28	787.8421	-2412.90	158.4	792.8382	-52.0
29	73.97878	5111.976	249.1	74.44792	3.629
30	-291.801	921.0689	165.8	-293.652	-52.8
31	2007.519	-2450.31	594.6	2020.249	-490.
32	-209.254	1647.145	·152.9	-210.581	-19.5
33	1470.296	-3416.11	157.5	1479.620	-68.2
34	3228.813	-533.057	-15.0	3249.288	92.03
35	1544.874	1351.879	57.94	1554.671	66.63
36	809.3754	377.7399	-60.5	814.5080	-130.
37	1782.012	429.1299	22.25	1793.312	93.00
38	561.3614	145.2779	11.12	564.9212	43.26
39	164.8310	1742.828	193.0	165.8763	18.37
40	1507.216	-219.890	-12.4	1516.774	85.99
41	4890.188	-3540.87	291.7	4921.199	-405.
42	7888.377	2186.599	24.48	7938.400	88.88
44	16997.47	-4098.64	-33.1	17105.26	138.4
45	72.57820	-19.4232	-8.41	73.03845	31.63
46	9772.470	2887.943	48.85	9834.441	166.3
Total	70971.23	10764.57	10.74	71421.29	71.27

cont

S.No.	Tech Eft	(in %)	Int Ift	(in %)	Tec+Fin	(in %)
8	-7.36075	-2.71	-4.65335	-1.71	2.754083	1.016
9	99.63718	-1.84	34.14318	-0.63	-66.1258	1.226
24	21.24989	0.869	73.72413	3.016	52.33948	2.141
43	1186.367	11.46	2357.965	22.79	1164.074	11.25
1	14129.45	40.82	12541.44	36.23	-1677.60	-4.84
2	66.95566	46.20	48.06560	33.16	-19.3146	-13.3
3	-146.327	140.8	-194.295	186.9	-47.0402	45.26
4	1304.416	47.61	744.1162	27.15	-568.572	-20.7
5	721.1416	40.34	354.7386	19.84	-370.976	-20.7
6	-49.5545	-33.1	-82.3625	-55.1	-32.4937	-21.7
7	176.5831	49.48	135.6921	38.02	-42.0107	-11.7
10	-244.079	103.4	-24.3299	10.31	221.2972	-93.8
11	253.6273	-45.5	1047.357	-188.	792.1222	-142.
12	-279.227	-21.2	-543.329	-41.2	-262.331	-19.9
13	107.9333	-14.8	-90.3838	12.44	-199.001	27.40
14	-321.704	-8.92	-188.564	-5.23	135.1797	3.751
15	366.1278	8.074	350.7807	7.736	-17.6688	-0.38
16	21.45063	0.701	245.0558	8.014	223.4691	7.308
17	-77.4686	-38.9	-74.5125	-37.4	3.447419	1.732
18	33.40758	1.616	42.24953	2.044	8.630092	0.417
19	-317.323	77.94	208.7771	-51.2	528.1133	-129.
20	73.86329	5.535	183.0503	13.71	108.7186	8.147
21	69.03055	14.11	45.28609	9.262	-24.1822	-4.94
22	157.3882	6.676	366.6939	15.55	208.3076	8.837
23	62.34011	16.11	141.3675	36.54	78.63213	20.32
25	-93.2430	15.44	146.1858	-24.2	240.0201	-39.7
26	-275.684	42.09	-117.620	17.95	159.8127	-24.4
27	-234.329	98.03	40.54707	-16.9	276.3627	-115.
28	-92.3411	6.064	189.8845	-12.4	282.8112	-18.5
29	-44.0888	-2.14	-3090.93	-150.	-3046.56	-148.
30	62.79086	11.30	-135.009	-24.3	-198.198	-35.6
31	22.91344	-5.56	-4.90863	1.191	-27.9673	6.787
32	61.32632	5.694	-421.015	-39.0	-482.730	-44.8
33	731.5409	-33.7	-963.494	44.43	-1699.67	78.38
34	442.2533	12.52	372.0445	10.53	-73.0133	-2.06
35	-199.003	-8.52	-374.408	-16.0	-174.142	-7.46
36	-734.195	117.7	-1081.50	173.4	-342.653	54.96
37	-130.960	-6.79	-163.327	-8.47	-31.5367	-1.63
38	262.8970	20.13	332.6008	25.47	68.03665	5.210
39	-79.9589	-8.85	-925.905	-102.	-845.439	-93.6
40	250.9451	14.22	215.9256	12.24	-36.6108	-2.07
41	-2023.12	166.6	-571.052	47.04	1464.897	-120.
42	-522.800	-5.85	-671.031	-7.51	-144.916	-1.62
44	-367.638	-2.97	-281.320	-2.27	88.64956	0.717
45	101.9647	44.15	75.32377	32.62	-27.2875	-11.8
46	-2958.91	-50.0	-3852.09	-65.1	-874.414	-14.7
Total	11588.27	11.56	6436.961	6.423	-5224.80	-5.21

cont

S.No.	Gr+Tec	(in %)	Tot.Eft	(in %)	Con.91
8	-7.40743	-2.73	270.9038	100	718.4286
9	100.2690	-1.85	-5392.85	100	-21520.7
24	21.38465	0.875	2443.730	100	3120.725
43	1193.890	11.54	10345.41	100	13767.25
1	14219.05	41.08	34611.18	100	43556.88
2	67.38026	46.49	144.9207	100	186.5708
3	-147.254	141.6	-103.922	100	74.34044
4	1312.688	47.91	2739.778	100	3951.512
5	725.7147	40.60	1787.339	100	3233.651
6	-49.8687	-33.3	149.3430	100	318.5668
7	177.7029	49.80	356.8295	100	414.8103
10	-245.627	104.1	-235.839	100	90.90583
11	255.2357	-45.8	-556.987	100	-1006.91
12	-280.998	-21.3	1316.025	100	2415.083
13	108.6178	-14.9	-726.033	100	161.9289
14	-323.744	-8.98	3603.105	100	10620.80
15	368.4496	8.125	4534.364	100	8518.839
16	21.58666	0.705	3057.626	100	3301.943
17	-77.9599	-39.1	199.0239	100	563.9545
18	33.61944	1.626	2066.560	100	3640.810
19	-319.336	78.43	-407.115	100	46.68417
20	74.33169	5.570	1334.359	100	1769.123
21	69.46830	14.20	488.8953	100	1059.873
22	158.3863	6.719	2357.175	100	3143.954
23	62.73544	16.21	386.7892	100	467.5243
25	-93.8343	15.53	-603.892	100	-184.937
26	-277.433	42.35	-654.949	100	-1268.20
27	-235.815	98.65	-239.034	100	22.48338
28	-92.9267	6.103	-1522.52	100	-734.683
29	-44.3684	-2.16	2051.402	100	2125.381
30	63.18905	11.38	555.1980	100	263.3964
31	23.05875	-5.59	-412.056	100	1595.463
32	61.71522	5.730	1076.875	100	867.6212
33	736.1800	-33.9	-2168.44	100	-698.146
34	445.0578	12.60	3530.529	100	6759.342
35	-200.265	-8.58	2333.138	100	3878.013
36	-738.851	118.5	-623.452	100	185.9228
37	-131.790	-6.83	1928.155	100	3710.167
38	264.5641	20.26	1305.697	100	1867.058
39	-80.4659	-8.91	902.8400	100	1067.671
40	252.5365	14.31	1763.754	100	3270.971
41	-2035.94	167.7	-1213.85	100	3676.336
42	-526.115	-5.89	8931.168	100	16819.54
44	-369.970	-2.99	12357.66	100	29355.13
45	102.6113	44.43	230.9037	100	303.4819
46	-2977.68	-50.3	5911.367	100	15683.83
Total	11661.76	11.63	100211.1	100	171182.3

Note: For the name of the sectors see table 3.1.

changes for the whole period under study i.e 1979-80 to 1991-92. During this period while GDP manifested an increase of 200%, total primary energy requirement increased by only 100211.1 Ttoe from 70971.23 Ttoe to 171182.3 Ttoe, that is the energy use changes registered a growth of 141%. During this time period the components of energy changes all had a positive contribution, the contributions being 10.74%, 71.2% ,11% and 6.4% respectively, in contrast to the earlier periods where at least one source of change i.e the interaction effects used to be negative. The shares of the sub-components of interaction effects were -5.21% and 11.63%.

A study of the sectoral details shows that the average growth effect was negative for sectors like crude oil(9), other minerals(11), fertiliser(26), cement(30),iron and steel(32). The basic reasons as explained in the previous sections were the highly dependence on the imports of these sectors. The remaining sectors show a positive trend for the whole period. This effect was very significant for some sectors like cereals(1), other crops(4), animal husbandry(5), sugar(12), other food and beverages(14), cotton textile(15), other textiles(18), other non-metalic mineral products(31), non-ferrous metals(33), machineries(34,35,37), other manufacturings(40), and services except communication(41, 42, 44, 46). As far as the composition of final demand is concerned it helped in 24 sectors in reducing the energy requirements among which the most important being construction(44), rail transport(41), other food and beverages(14), other non-metalic mineral products(31), synthetic fiber and resin(28), other minerals(11), cereals(1) . Hence the negative effects of this factor in these sectors offset the high requirement of energy to a great extent.

The effect of technical change on energy requirements showed a decline in energy use of sectors like tea & coffee(3), forest(6), coal(8), other minerals(10), sugar(12), other food and beverages(14), art silk & synthetic(17), wood & wood products(19), coal tar products(25), chemicals(26, 27, 28, 29), electrical machineries(35), equipments except other transport equipments(36,

37, 39), services except communication(41, 42, 44, 46). This change reflects either the intensity of energy had reduced in the sectors i.e there was an improvement in the energy productivity or there was a decline in the size and weight of items produced with these materials. On the other hand the change in I-O coefficients had manifested in an increase in the energy use in the following sectors; cereals(1), cash crops(2), other crops(4), fishing(7), crude oil(9), other minerals(11), khandsari(13), textiles except art silk(15, 16, 18), primary sector related products(20, 21, 22, 23, 24), metalic products(30, 31, 32, 33), non-electrical machineries(34), other transport equipments(38), other manufacturings(40), electricity(43), communication(45).

The share of the interaction factors in the total primary energy use change over the whole period spreading over 1979-80 to 1991-92 was only 6.4% . However, as in other periods, in this period also it was very significant with positive contribution in sectors like cereals(1), other crops(4), animal husbandry(5), fishing(7), crude oil(9), sugar(12), cotton textiles(15), woolen textiles(16), wood & wood products(19), leather & leather products(22), non-electrical machineries(34), other transport equipments(38), other manufacturings(40), electricity(43). On the other hand the reverse impact was experienced by the sector like other chemicals(29), iron & steel(32), non-ferrous metals(33), electrical machineries(35), rail equipments(36), electronics & communication equipments(39), transport services(41, 42) and other services(46). The importance of the interaction effects shows that the final demand effect, growth effect, and the technology effects would have given a different picture if this interaction effects had not been separated out.

5.3. Contributions of Final Demand Categories to the Changes in Energy Uses.

In this section of this chapter changes in energy use due to the composition of final demand are broken down into changes in five final demand sub-components viz; (i) Private consumption,

(ii) Government consumption, (iii) Gross Fixed Investment, (iv) Change in Stock, (v) Export and (vi) Import. This is done, as explained in the previous chapter where the energy embodied in the final demand categories had been computed, to capture the separate effects of changes in different components of final demand on the change in energy uses. This analysis is also done for the same time periods for which the SDA of energy use is done in the previous section of this chapter. This sort of decomposition will help in identifying, since it depicts the ways in which various policies affect the individual components of final demand, the effects of economic policies on the energy use changes. The result of this analysis is shown in the Tables 5.6 to 5.9 for the periods 1979-80 to 1984-85, 1984-85 to 1989-90, 1989-90 to 1991-92, and 1979-80 to 1991-92 respectively.

Table 5.6 shows the percentage contribution of each components of final demand to changes in energy use changes during 1979-80 to 1984-85. The figures across each row in all the table sums to 100%. During the period 1979-80 to 1984-85 energy requirement had increased by 24576.53 Ttoe or by 74.67% of the total changes. The shares of the five components of final demand were 25.9%, -3.9%, -0.8%, 10.7%, 32%, and 20.5% respectively. Further table 5.6 reveals that we can attribute 19035.2 Ttoe (77.53%) of the demand related energy use increased due to the purchase of final customers, with 5541.33 Ttoe(22.47%) being related to the purchase of non-energy products. This shows that during this period, the final demand of India were very less energy intensive.

Consumption expenditure, which includes both the private consumption and government consumption, helped in reducing the energy requirements in sectors like other non-metalic mineral products(31), cotton textiles(15), construction(44), synthetic fiber and resin(28), other manufacturings(40), non-ferrous metal products(33), motor vehicles(37), other services(46), animal husbandry(5). While sectors like transport services(41,42), other chemicals(29), other textiles(18), cereals(1), sugar(12), woolen textiles(16), pesticides(27), paper & paper products(20) augmented India's energy use through the final consumption.

Table 5.6 Shares of Final Demand Components during 1979-80 to 1984-85

S.N.	PFCE	(in %)	GFCE	(in %)	GFCF	(in %)	CHIS	(in %)
8	-168.8	-4.598	-157.4	-4.287	0	0	2786.0	75.874
9	0	0	0	0	0	0	-287.4	-2.003
24	-670.7	-792.9	590.79	698.48	0	0	-303.4	-358.7
43	-1308.	-140.5	2249.6	241.59	0	0	0	0
1	630.13	46.174	-9.098	-0.666	0	0	1348.8	98.837
2	0	0	0	0	0	0	21.168	123.90
3	-68.33	-11.73	0	0	0	0	-300.0	-51.52
4	-100.1	98.763	-9.744	9.6060	0	0	26.766	-2638.
5	-310.1	95.075	1.8061	-0.553	-11.33	3.4743	5.0198	-1.538
6	-155.1	106.85	-2.226	1.5334	0	0	12.582	-8.665
7	-30.54	100.33	0.0363	-0.119	0	0	0	0
10	0	0	0	0	0	0	-73.86	53.59
11	0	0	4.1249	-1.515	0	0	52.035	-19.11
12	545.79	223.15	9.8314	4.0196	0	0	-184.2	-75.31
13	130.80	93.453	0	0	0	0	11.223	8.0185
14	-33.20	6.3107	22.079	-4.196	0	0	444.77	-84.54
15	-1081.	59.246	-243.1	13.315	0	0	-688.5	37.710
16	502.33	112.77	0.0981	0.0220	0	0	-66.45	-14.91
17	-76.56	60.493	50.932	-40.24	0	0	-117.7	92.998
18	957.53	220.71	-63.27	-14.58	-27.10	-6.248	-575.9	-132.7
19	-299.2	501.28	44.617	-74.74	173.40	-290.5	-47.90	80.249
20	257.06	-411.8	-61.31	98.238	0	0	-242.7	388.96
21	-2.611	1.8735	3.6833	-2.642	-1.057	0.7590	-125.8	90.332
22	14.603	-11.22	0	0	-243.5	187.14	28.389	-21.81
23	93.636	141.58	-36.88	-55.77	0	0	-81.26	-122.8
25	-56.24	-7.651	-29.68	-4.038	0	0	724.21	98.527
26	0	0	-31.98	6.9462	0	0	449.54	-97.61
27	407.30	166.31	4.7882	1.9552	0	0	-335.8	-137.1
28	-1018.	87.337	-3.441	0.2951	0	0	-104.7	8.9884
29	1780.6	119.41	-225.9	-15.15	0	0	214.51	14.385
30	0	0	0	0	0	0	124.49	21.391
31	-1559.	241.40	-3.491	0.5403	-139.5	21.594	-294.9	45.652
32	0	0	0	0	-1989.	358.37	1085.2	-195.4
33	-744.3	32.942	-170.6	7.5520	-1042.	46.131	-334.0	14.782
34	-214.9	20.812	-1.121	0.1085	-289.1	27.993	73.985	-7.162
35	129.08	28.470	-23.67	-5.222	460.70	101.61	-93.83	-20.69
36	0	0	0	0	-501.6	109.00	82.532	-17.93
37	-93.53	-55.06	-635.7	-374.2	1176.1	692.35	-440.5	-259.3
38	86.565	49.059	-71.20	-40.35	34.098	19.325	50.977	28.890
39	236.70	121.00	65.524	33.496	50.437	25.783	-79.18	-40.48
40	-766.2	103.83	353.08	-47.84	246.51	-33.40	-130.2	17.653
41	2029.4	142.64	-894.0	-62.83	148.81	10.459	0	0
42	7774.4	121.87	-1001.	-15.70	10.978	0.1721	0	0
44	0	0	-1072.	-59.19	2286.3	126.18	0	0
45	-17.62	-116.7	32.180	213.20	0	0	0	0
46	-429.8	188.42	351.41	-154.0	-559.7	245.38	0	0
Tot	6369.5	25.917	-964.0	-3.922	-217.9	-0.886	2633.5	10.715

cont.

S.N.	EXP	(in %)	IMP	(in %)	-(g-h)	(in %)	Total	(in %)
8	37.899	1.0321	-1005.	-27.37	168.93	4.6007	3671.9	100
9	6677.1	46.538	-8636.	-60.19	-678.3	-4.727	14347.	100
24	1201.4	1420.4	254.01	300.32	-479.5	-566.9	84.581	100
43	0	0	0	0	-9.967	-1.070	931.16	100
1	-88.83	-6.509	102.25	7.4933	-414.0	-30.34	1364.6	100
2	-17.71	-103.6	6.8059	39.837	20.433	119.60	17.084	100
3	794.89	136.50	-42.41	-7.283	113.34	19.465	582.30	100
4	-24.07	23.738	8.0519	-7.937	13.855	-13.65	-101.4	100
5	-4.938	1.5139	5.3299	-1.634	-1.289	0.3952	-326.1	100
6	-10.43	7.1894	1.0630	-0.732	11.105	-7.647	-145.2	100
7	0.5131	-1.685	0.3169	-1.040	-0.131	0.4326	-30.44	100
10	-143.9	104.47	-0.473	0.3432	79.554	-57.72	-137.8	100
11	-31.59	11.606	281.75	-103.4	-15.05	5.5290	-272.2	100
12	-36.95	-15.10	67.669	27.667	-22.21	-9.082	244.58	100
13	-0.464	-0.331	0	0	-1.596	-1.140	139.96	100
14	-1093.	207.91	127.68	-24.27	261.74	-49.75	-526.0	100
15	-98.55	5.3982	2.4986	-0.136	288.62	-15.80	-1825.	100
16	-18.28	-4.104	5.8492	1.3131	33.602	7.5435	445.44	100
17	-27.21	21.498	3.3460	-2.643	47.329	-37.39	-126.5	100
18	-149.0	-34.35	23.977	5.5268	315.65	72.759	433.83	100
19	-15.52	26.009	0.3013	-0.504	85.237	-142.7	-59.69	100
20	-11.00	17.628	159.09	-254.9	154.68	-247.8	-62.40	100
21	-89.72	64.381	3.9727	-2.850	80.212	-57.55	-139.3	100
22	10.478	-8.051	24.115	-18.52	84.064	-64.59	-130.1	100
23	-29.83	-45.11	-83.78	-126.6	36.697	55.490	66.133	100
25	-144.1	-19.61	-16.04	-2.182	224.90	30.597	735.03	100
26	0	0	963.12	-209.1	85.066	-18.47	-460.5	100
27	46.540	19.004	63.867	26.079	185.98	75.946	244.89	100
28	-125.9	10.800	2.0163	-0.172	88.531	-7.594	-1165.	100
29	439.08	29.446	972.63	65.227	255.51	17.135	1491.1	100
30	-5.811	-0.998	-427.5	-73.46	35.746	6.1423	581.97	100
31	1128.6	-174.6	31.897	-4.936	254.98	-39.46	-646.1	100
32	-632.1	113.85	-492.7	88.752	488.67	-88.01	-555.2	100
33	-489.1	21.647	-291.5	12.901	229.46	-10.15	-2259.	100
34	-5.314	0.5144	800.04	-77.44	203.66	-19.71	-1033.	100
35	-46.56	-10.27	58.376	12.875	86.068	18.983	453.39	100
36	-58.93	12.805	23.845	-5.181	41.695	-9.059	-460.2	100
37	-18.05	-10.62	50.205	29.554	231.79	136.45	169.87	100
38	-45.13	-25.58	-74.34	-42.13	46.809	26.528	176.44	100
39	-8.049	-4.115	107.89	55.154	38.078	19.465	195.61	100
40	-606.9	82.252	18.425	-2.496	184.35	-24.98	-737.9	100
41	41.529	2.9189	0	0	97.005	6.8182	1422.7	100
42	1018.8	15.972	1527.4	23.945	103.90	1.6289	6378.8	100
44	0	0	0	0	598.22	33.014	1811.9	100
45	0	0	0	0	0.5331	3.5324	15.093	100
46	569.52	-249.6	341.79	-149.8	182.34	-79.93	-228.1	100
Tot	7888.2	32.096	-5030.	-20.47	3836.2	15.609	24576.	100

Note: 1. The import component should be deducted from the total.
2. For the sector name see Table 3.1.

As far as the investment (both GFCF and CHIS) is concerned, though it had a positive contribution to the energy use changes, disaggregated sectoral level studies reveal that sectors like construction(44), motor vehicles(37), cereals(1), coal tar products(25), other food and beverages(14) had augmented the energy requirements of the economy through its investment component. Whereas sectors like non-ferrous metals(33), other services(46), rail equipments(36), other textiles(18), motor vehicles(37), cotton textiles(15), pesticides(27), tea and coffee(3), petroleum products(24), crude oil(9) helped in reducing the energy requirements through its investment component. On the other hand export demand was relatively important for sectors like crude oil(9), petroleum products(24), tea and coffee(3), iron and ore(10), other food and beverages(14), other textiles(18), coaltar products(25), synthetic fiber and resin(28), other chemicals(29), non-metalic mineral products(31), iron & steel(32), non-ferrous metal(33), other manufacturings(40), rail transport(42), and other services(46) out of which the sectors which helped in reducing energy consumption in order of importance were other food and beverages(14), iron & steel(32), other manufacturing(40), non-ferrous metals(33), other textiles(18), coal tar products(25), iron ore(10), and synthetic fiber and resin, where as the remaining sectors contributed positively. A negative impact of export on energy requirements of any sectors implies that the energy consumption of that sector has reduced due to a decline in export quantity. Whereas a negative impact of import on energy requirement means that the energy consumption of that sectors, for which the impact is negative, has increased due to a fall in imports since domestic supply has to increase to fill the gap which ultimately increases the energy requirements. Hence it is clear from the Table 5.6 that the energy consumption had increased due to a fall in imports in sectors like crude oil(9), coal & lignite(8), iron & steel(32), cement(30), and non-ferrous products(33). While the opposite effects were felt in other transport(42), other chemicals(29), fertiliser(26), non-electrical machineries(34), other services(46), other minerals(11), petroleum products(24), paper & paper products(20), other food and

Table 5.7 Shares of Final Demand Components during 1984-85 to 1989-90.

S.N.	PFCE	(IN %)	GFCE	(IN %)	GFCF	(IN %)	CHIS	(IN %)
8	-882.0	12.826	-121.9	1.7732	0	0	-2154.	31.332
9	0	0	0	0	0	0	1082.4	-12.55
24	353.41	6.7227	-80.88	-1.538	0	0	-764.3	-14.53
34	1237.0	49.457	1036.0	41.423	0	0	0	0
1	-2641.	108.06	-97.37	3.9833	0	0	27.477	-1.124
2	0	0	0	0	0	0	-191.5	56.318
3	0	0	0	0	0	0	-0.187	0.0388
4	-94.14	189.81	-22.05	44.467	0	0	-52.33	105.51
5	-239.8	-424.8	-2.101	-3.721	275.29	487.64	1.9811	3.5093
6	369.47	132.04	1.0647	0.3805	0	0	-27.34	-9.770
7	11.308	36.568	-0.050	-0.161	0	0	0.0115	0.0373
10	0	0	0	0	0	0	-7.910	-18.35
11	0	0	-15.74	2.7193	0	0	378.78	-65.41
12	-182.4	-268.1	-8.383	-12.32	0	0	127.36	187.17
13	-1091.	100.90	0	0	0	0	-7.480	0.6915
14	-777.9	86.239	-22.98	2.5483	0	0	-380.8	42.213
15	1871.9	92.266	-32.01	-1.578	0	0	24.196	1.1926
16	3579.6	79.664	-0.281	-0.006	0	0	763.75	16.997
17	181.70	125.65	-42.75	-29.56	0	0	6.9526	4.8078
18	-40.94	-2.215	13.923	0.7536	530.94	28.736	43.513	2.3551
19	-38.97	8.5141	-49.17	10.742	-173.5	37.917	-117.0	25.566
20	38.482	18.266	124.30	59.004	0	0	-59.13	-28.06
21	-155.9	120.04	-6.422	4.9447	0	0	3.9750	-3.060
22	251.96	107.04	17.492	7.4312	-44.03	-18.70	-76.56	-32.52
23	-259.8	898.23	-1.964	6.7931	0	0	207.66	-717.9
25	0	0	0	0	0	0	-1261.	50.812
26	0	0	202.80	7.9587	0	0	-480.5	-18.86
27	-717.1	122.99	-12.73	2.1846	0	0	80.306	-13.77
28	0	0	0	0	0	0	2208.3	117.94
29	2298.7	128.03	90.393	5.0346	0	0	-435.5	-24.26
30	0	0	0	0	0	0	-438.8	82.783
31	573.52	34.672	0.0675	0.0040	-25.02	-1.512	-229.7	-13.88
32	0	0	0	0	1800.3	-65.45	-1507.	54.799
33	0	0	0	0	0	0	-135.7	16.607
34	-151.5	90.420	169.56	-101.1	2653.9	-1583.	-11.30	6.7441
35	-302.5	-176.5	-34.58	-20.17	649.41	378.84	99.956	58.310
36	0	0	0	0	635.90	136.27	-79.57	-17.05
37	-45.46	62.872	96.433	-133.3	-69.07	95.539	2.8069	-3.882
38	-59.21	-181.3	1.3086	4.0083	266.14	815.17	209.94	643.02
39	160.48	15.550	-63.55	-6.158	714.68	69.249	391.64	37.948
40	1306.2	138.45	-191.9	-20.34	571.92	60.618	-20.23	-2.145
41	-2881.	107.12	-123.2	4.5816	-117.4	4.3679	0	0
42	-6017.	80.113	-351.5	4.6798	-489.7	6.5203	0	0
44	0	0	1472.0	-18.37	-9436.	117.81	0	0
45	-3.373	3.3103	-101.6	99.786	0	0	0	0
46	1393.1	74.499	67.377	3.6031	28.205	1.5083	0	0
Tot	-2956.	16.314	1909.4	-10.53	-2228.	12.295	-2778.	15.330

cont.

S.N.	EXP	(IN %)	IMP	(IN %)	-(g-h)	(IN %)	Total	(IN %)
8	-76.93	1.1187	1578.3	-22.95	-2062.	29.997	-6876.	100
9	-11491	133.34	-11943	138.58	-10152	117.80	-8618.	100
24	1413.1	26.881	-11246	-213.9	-6911.	-131.4	5256.9	100
34	0	0	0	0	228.08	9.1188	2501.2	100
1	-16.48	0.6741	-172.7	7.0676	110.75	-4.530	-2444.	100
2	-23.60	6.9427	-9.188	2.7019	-134.1	39.440	-340.0	100
3	-596.8	123.74	0	0	114.70	-23.78	-482.3	100
4	52.892	-106.6	-53.99	108.86	12.050	-24.29	-49.59	100
5	1.5637	2.7699	16.068	28.463	35.627	63.108	56.453	100
6	-28.92	-10.33	19.211	6.8659	-15.24	-5.447	279.81	100
7	17.512	56.627	-0.939	-3.037	1.2032	3.8906	30.925	100
10	16.122	37.402	0	0	34.893	80.949	43.105	100
11	94.906	-16.38	-1136.	196.18	-2173.	375.27	-579.0	100
12	-13.92	-20.45	-66.25	-97.37	79.163	116.34	68.043	100
13	0	0	0	0	17.236	-1.593	-1081.	100
14	-190.3	21.104	-855.0	94.783	-384.9	42.677	-902.0	100
15	-9.224	-0.454	7.4890	0.3691	181.43	8.9426	2028.8	100
16	133.54	2.9720	-25.61	-0.569	-8.881	-0.197	4493.3	100
17	0.9719	0.6720	6.3562	4.3953	4.0928	2.8302	144.61	100
18	1083.9	58.665	-34.04	-1.842	182.21	9.8620	1847.5	100
19	-5.307	1.1594	4.7780	-1.043	-68.92	15.056	-457.7	100
20	-15.85	-7.524	-371.3	-176.2	-248.4	-117.9	210.67	100
21	-24.31	18.722	-1.840	1.4168	50.960	-39.23	-129.8	100
22	117.44	49.892	-29.66	-12.60	-60.57	-25.73	235.38	100
23	39.974	-138.2	2.9836	-10.31	-11.81	40.856	-28.92	100
25	2.5765	-0.103	393.18	-15.83	-830.6	33.455	-2482.	100
26	2.7984	0.1098	-6487.	-254.5	-3663.	-143.7	2548.1	100
27	88.543	-15.18	-154.5	26.500	-176.5	30.280	-583.0	100
28	43.407	2.3183	-257.2	-13.73	-636.6	-34.00	1872.3	100
29	93.706	5.2191	-846.0	-47.12	-1097.	-61.15	1795.4	100
30	-30.77	5.8042	-334.5	63.094	-395.0	74.507	-530.1	100
31	1173.0	70.915	-57.00	-3.446	105.23	6.3620	1654.1	100
32	34.651	-1.259	-38.10	1.3852	-3116.	113.29	-2750.	100
33	34.066	-4.166	70.217	-8.588	-645.6	78.971	-817.5	100
34	174.24	-103.9	1027.4	-613.1	-1975.	1178.5	-167.5	100
35	76.634	44.705	167.23	97.560	-150.2	-87.62	171.42	100
36	-1.745	-0.374	1.1009	0.2359	-86.84	-18.61	466.63	100
37	-21.64	29.940	-13.59	18.802	-48.95	67.703	-72.30	100
38	104.15	319.01	302.02	925.06	-187.6	-574.7	32.649	100
39	133.47	12.932	173.44	16.806	-131.2	-12.71	1032.0	100
40	-275.7	-29.22	248.37	26.325	-198.4	-21.02	943.47	100
41	150.44	-5.592	0	0	282.08	-10.48	-2689.	100
42	-171.8	2.2882	158.29	-2.107	-322.2	4.2904	-7511.	100
44	0	0	0	0	-45.13	0.5634	-8009.	100
45	8.6088	-8.447	13.696	-13.43	8.2438	-8.088	-101.9	100
46	-497.5	-26.60	-417.0	-22.30	461.67	24.689	1869.9	100
Tot	-8400.	46.348	-30361	167.51	-34031	187.76	-18124	100

Note: 1. The import component should be deducted from the total.
2. For sector name see Table 3.1.

beverages(14), electronics & communication equipments(39), and cereals(1) during the period under study i.e 1979-80 to 1984-85.

The results of similar computations for the period 1984-85 to 1989-90 are presented in Table 5.7. During this period the effect of the sub-components of the composition of final demand categories were 16.31%, -10.5%, 12.29%, 15.33%, 46.34%, 16.75%, 187.7% respectively. Hence as compared to the previous period i.e. 1979-80 to 1984-85, during this period, on the one hand total domestic demand had a higher share though the share of consumption demand had declined while on the other hand, the share of foreign trade had reduced the requirement to a great extent.

From table 5.7 we can have a detailed idea about the behaviours of the individual sectors. It is seen from the table that transport(42, 41), cereals(1), khandsari & gur(13), other food and beverages(14), coal(8), pesticides(27), electrical machineries(35) were the sector where consumption helped in reducing the energy use while sectors like woolen textiles(16), other chemicals(29), cotton textiles(15), construction(44), other services(46), electricity(43), other manufacturings(40), other non-metalic mineral products(31), forest and logging(6) had experienced a positive effect due to consumption. Hence a comparison between the previous periods shows that while sectors like motor vehicles(37), forestry & logging(6) were reducing the energy use during 1979-80 to 1984-85, it augmented the requirements during this period. On the other hand while sectors like transport(41, 42), pesticides(27), cereals(1) which were having a positive contribution in the earlier period had reversed the contributions during 1984-85 to 1989-90. Similar was the case for investment, while sectors like construction(44), coal(8), coal tar product(25), other transport(42), petroleum products(24), other chemicals(29), fertiliser(26), cement(30) were having a negative effect in the total energy use during 1984-85 to 1989-90, some of these sectors like construction(44), coaltar product(25) were having a positive effect during the earlier period. Similarly whereas non-electrical machineries(34), synthetic fiber and resin(28), crude oil(9), woolen textiles(16), electronics &

communication equipments(39), electrical machineries(35), rail equipments(36), other manufacturings(40), other textiles(18) were positively contributing during 1984-85 to 1989-90, out of these sectors like crude oil(9),rail equipments(36), other textiles(18) had an opposite effect during the earlier period.

During 1984-85 to 1989-90 the sectors that helped in reducing the energy requirements of the Indian economy through the change in exports, in order of importance in absolute terms, were sector like crude oil(9), tea & coffee(3), other sectors(46), other manufacturings(40), other food and beverages(14), rail transport(42), whereas it had an opposite effect for sector like petroleum products(24), other non-metalic products(31), other textiles(18),non-electrical machineries(34), woolen textiles(16), plastic & plastic products(22), other transport equipments(38), and electronics & communication equipments(39). Similarly import changes favoured in reducing the energy uses for some sectors like crude oil(9), petroleum products(24), fertiliser(26), cement(30), other minerals(11), other food and beverages(14), other services(46), other chemicals(29), paper & paper products(20), and cereals(1). Whereas in sectors like coal(8), non-electrical machineries(34), coaltar products(25), other transport equipments(38), other services(40), electrical machineries(35), and other transport(42), the import change resulted in an increase in energy requirements.

The results of the final demand components contributions for the third sub-period ranging from 1989-90 to 1991-92 is shown in Table 5.8. During this period, energy use increased by 3588.05 Ttoe due to the composition of final demand, which accounted for 9% of the total changes of this period. As is seen from the table investment demand (both GFCF and CHIS) contributed 259.78%, while the consumption demand had a negative contributon of -21.38%. The shares of export and import changes were -106.15% and -92.58% respectively.

The Table 5.8 clearly shows that during this period, there were 20 sectors where the consumption demand caused a reduction in

Table 5.8 Share of Final Demand Components during 1989-90 to 1991-92.

S.N.	PFCE	(in %)	GFCE	(in %)	GFCF	(in %)	CHIS	(in %)
8	-109.1	-7.220	-50.19	-3.319	0	0	2807.3	185.63
9	0	0	0	0	0	0	2015.7	-94.13
24	-919.4	30.613	-245.8	8.1846	0	0	460.94	-15.34
43	-3020.	344.42	2141.4	-244.1	0	0	0	0
1	-128.1	26.516	-2.674	0.5533	0	0	-273.8	56.668
2	0	0	0	0	0	0	-1.794	-0.886
3	0	0	0	0	0	0	0	0
4	-792.7	114.64	-0.717	0.1037	0	0	24.018	-3.473
5	-149.0	39.255	0.2835	-0.074	-274.4	72.274	19.183	-5.051
6	27.031	257.16	0.1368	1.3020	0	0	-0.454	-4.323
7	-4.414	-345.2	-0.000	-0.063	0	0	-0.003	-0.286
10	0	0	0	0	0	0	-5.408	5.0036
11	0	0	0	0	0	0	-149.1	16.553
12	353.74	89.864	0	0	0	0	15.737	3.9977
13	-34.31	99.990	0	0	0	0	0.0300	-0.087
14	-208.8	96.024	-1.167	0.5368	0	0	105.91	-48.69
15	80.559	9.7373	-0.018	-0.002	0	0	154.78	18.709
16	-355.9	62.658	0	0	0	0	-90.82	15.988
17	-38.25	66.365	0	0	0	0	-4.272	7.4116
18	-747.5	34.942	1.0806	-0.050	-554.2	25.909	-11.18	0.5228
19	14.630	-129.2	1.0825	-9.565	-30.95	273.53	5.7226	-50.56
20	52.763	16.716	182.10	57.694	0	0	83.487	26.450
21	-45.95	-21.26	0.0150	0.0069	0	0	0.3701	0.1712
22	-10.13	-2.596	-0.133	-0.034	235.91	60.431	1.5550	0.3983
23	25.031	114.62	0.0028	0.0129	0	0	55.274	253.10
25	0	0	0	0	0	0	163.35	331.18
26	0	0	-52.69	12.011	0	0	-184.5	42.063
27	0	0	-0.018	0.5019	0	0	7.7908	-213.8
28	0	0	0	0	0	0	20.028	-1.745
29	-577.1	452.15	11.317	-8.866	0	0	11.931	-9.347
30	0	0	0	0	0	0	278.71	101.51
31	28.968	-0.788	0.0500	-0.001	13.773	-0.374	105.07	-2.859
32	0	0	0	0	1001.9	14.645	14.472	0.2115
33	0	0	0	0	0	0	365.79	11.733
34	150.65	8.6160	110.80	6.3368	1867.9	106.83	141.18	8.0747
35	431.68	81.496	1.2310	0.2324	224.05	42.299	1.4187	0.2678
36	0	0	0	0	81.993	52.182	87.684	55.804
37	742.61	249.63	609.44	204.86	-1022.	-343.7	0.3983	0.1339
38	394.06	-258.2	0.3303	-0.216	-24.68	16.175	-24.80	16.255
39	512.85	849.92	3.3024	5.4729	78.269	129.71	-123.5	-204.7
40	-858.1	-304.5	107.27	38.070	-804.3	-285.4	-45.31	-16.08
41	-551.6	52.782	-219.7	21.023	-48.99	4.6878	0	0
42	2659.5	125.29	363.45	17.122	31.274	1.4733	0	0
44	0	0	-1206.	-73.84	2557.2	156.54	0	0
45	23.551	77.246	9.9525	32.643	0	0	0	0
46	604.12	82.617	-31.43	-4.298	-43.72	-5.978	0	0
Tot	-2449.	-68.27	1732.4	48.284	3288.5	91.651	6032.8	168.13

cont.

S.N.	EXP	(in %)	IMP	(in %)	-(g-h)	(in %)	Total	(in %)
8	-80.31	-5.310	432.53	28.602	-622.8	-41.18	1512.2	100
9	0	0	1218.9	-56.92	-2938.	137.20	-2141.	100
24	-913.4	30.414	1662.6	-55.35	277.03	-9.224	-3003.	100
43	0	0	0	0	2.0778	-0.236	-876.9	100
1	-39.38	8.1512	-79.46	16.444	-118.6	24.554	-483.2	100
2	187.97	92.899	-16.35	-8.082	-0.192	-0.095	202.34	100
3	17.901	74.198	0	0	6.2249	25.801	24.126	100
4	31.955	-4.621	-1.428	0.2066	44.600	-6.449	-691.4	100
5	0.7008	-0.184	-25.62	6.7483	-2.009	0.5292	-379.7	100
6	0	0	14.134	134.46	-2.068	-19.67	10.511	100
7	3.1720	248.09	0.0161	1.2639	2.5412	198.75	1.2785	100
10	-176.5	163.35	0	0	73.885	-68.35	-108.0	100
11	42.737	-4.743	467.80	-51.92	-326.6	36.263	-900.8	100
12	-3.322	-0.844	-28.23	-7.173	-0.753	-0.191	393.64	100
13	0	0	0	0	-0.033	0.0972	-34.32	100
14	-122.2	56.208	65.121	-29.93	73.991	-34.01	-217.5	100
15	470.51	56.872	12.503	1.5113	133.98	16.194	827.32	100
16	64.525	-11 35	34.368	-6.050	-151.4	26.662	-568.0	100
17	3.1289	-5.427	14.823	-25.71	-3.421	5.9360	-57.64	100
18	-1291.	60.362	31.675	-1.480	495.62	-23.16	-2139.	100
19	1.4866	-13.13	3.6140	-31.93	0.3304	-2.919	-11.31	100
20	-5.720	-1.812	-62.33	-19.74	-59.32	-18.79	315.63	100
21	178.74	82.722	5.8458	2.7053	88.752	41.073	216.07	100
22	139.42	35.713	14.873	3.8098	38.635	9.8966	390.38	100
23	23.379	107.05	12.689	58.108	-69.16	-316.6	21.838	100
25	3.4190	6.9315	54.481	110.45	-62.97	-127.6	49.326	100
26	-0.542	0.1235	-35.14	8.0112	-236.0	53.812	-438.7	100
27	-6.131	168.29	-0.631	17.325	-5.915	162.35	-3.643	100
28	2.8952	-0.252	728.76	-63.49	-441.8	38.500	-1147.	100
29	427.63	-335.0	-21.83	17.107	-23.21	18.183	-127.6	100
30	0	0	3.6485	1.3288	-0.508	-0.185	274.56	100
31	-4659.	126.80	41.262	-1.122	878.26	-23.90	-3674.	100
32	-144.7	-2.115	-6830.	-99.82	-860.0	-12.57	6841.7	100
33	1.2109	0.0388	-3311.	-106.2	-560.8	-17.99	3117.5	100
34	-16.68	-0.954	-119.2	-6.817	-624.6	-35.72	1748.5	100
35	39.749	7.5041	130.20	24.580	-38.24	-7.219	529.69	100
36	0.5831	0.3711	14.322	9.1154	1.1890	0.7567	157.12	100
37	52.544	17.662	156.02	52.447	71.005	23.868	297.48	100
38	-3.708	2.4305	324.81	-212.8	-168.9	110.73	-152.5	100
39	-8.215	-13.61	283.35	469.58	-118.9	-197.1	60.341	100
40	2771.6	983.61	795.11	282.18	-94.10	-33.39	281.77	100
41	-375.9	35.969	0	0	151.17	-14.46	-1045.	100
42	-502.9	-23.69	595.31	28.045	166.54	7.8458	2122.6	100
44	0	0	0	0	282.55	17.297	1633.5	100
45	-2.937	-9.634	0.6246	2.0489	0.5468	1.7936	30.489	100
46	79.546	10.878	90.191	12.334	212.90	29.115	731.23	100
Tot	-3808.	-106.1	-3322.	-92.58	-4529.	-126.2	3588.0	100

Note 1. The import component should be deducted from the total.
2. For the Sector name see Table 3.1.

energy use, the most important among them being construction(44), petroleum products(24), electricity(43), rail transport(41), other manufacturing(40), other chemicals(29), other textiles(18) etc. The sectors where consumption augmented the energy uses were other transport(42), communication & electronic equipments(39), motor vehicles(37), sugar(12), electrical machinery(35), other services(46) etc.

As far as the share of investment is concerned, the sectors like motor vehicles(37), other manufacturing(40), cereals(1), fertiliser(26), other metalic minerals(11) had experienced a fall in energy demand due to this factor while the sectors which experienced an increase in their energy requirements were sectors like coal & lignite(8), crude oil & N.gas(9), petroleum products(24), non-ferrous metals(33), non-electrical machinery(34).

Likewise the export and import demand reduced the energy needs of 18 and 28 sectors respectively. The important 5 sectors in which the export demand had reduced the energy needs were other non-metalic mineral products(31), other textiles(18), petroleum products(24), other transport services(42), iron ore(10) while the important 5 sectors where the import demand reduced the energy consumption were petroleum products(24), oil & N.gas(9), other manufacturing(40), synthetic fiber and resin (28), other transport services(42).

And finally, before concluding this section, we will analyse the decomposition of final demand change in energy requirements into its constituent sub-components for the whole period covered in this study i.e. 1979-80 to 1991-92, which is shown in the Table 5.9. During this period the primary energy requirements had changed by 10764.57 Ttoe(10.74%) due to the composition of final demand. Out of this the respective shares of consumption demand, investment demand, export, and import were 16.4%, 58.1%, 12.13%, and -429% respectively while the share of the g-h was -407%.

At a disaggregated level, it is clear from the table 5.9 that

Table 5.9 Share of Final Demand Components during 1979-80 to 1991-92

S.N.	PFCE	(in %)	GFCE	(in %)	GFCF	(in %)	CHIS	(in %)
8	-1347.	805.04	-399.8	238.77	0	0	2995.1	-1788.
9	0	0	0	0	0	0	2523.1	23.573
24	-1835.	-110.1	564.63	33.861	0	0	-14.28	-0.856
43	-3376.	-100.5	6614.8	197.01	0	0	0	0
1	-2118.	199.46	-127.3	11.989	0	0	511.05	-48.11
2	0	0	0	0	0	0	-23.59	196.36
3	-107.2	-187.1	0	0	0	0	-158.3	-276.3
4	-606.5	114.84	-29.45	5.5775	0	0	8.2336	-1.558
5	-791.3	106.35	1.4378	-0.193	-2.709	0.3641	18.031	-2.423
6	222.29	200.32	-2.130	-1.920	0	0	-11.31	-10.19
7	-44.36	321.61	0.0071	-0.052	0	0	0	0
10	0	0	0	0	0	0	-54.45	18.382
11	0	0	0	0	0	0	-6.777	0.4822
12	981.94	95.098	-0.155	-0.015	0	0	58.736	5.6884
13	-1665.	101.72	0	0	0	0	-1.027	0.0627
14	-1931.	65.489	-12.24	0.4151	0	0	-24.98	0.8471
15	176.97	-92.03	-421.5	219.23	0	0	-226.9	118.04
16	2384.6	93.688	0	0	0	0	97.163	3.8174
17	162.89	-1003.	0	0	0	0	-61.94	381.43
18	402.29	98.923	-79.70	-19.60	-24.79	-6.097	-283.6	-69.74
19	-486.3	64.396	6.3376	-0.839	-53.14	7.0364	-100.8	13.348
20	532.88	83.273	331.30	51.773	0	0	-106.5	-16.65
21	-300.4	150.21	-4.312	2.1558	-1.640	0.8199	-62.45	31.224
22	518.37	49.780	35.445	3.4039	-8.797	-0.844	-68.92	-6.619
23	-2.642	-2.594	-60.55	-59.46	0	0	81.694	80.223
25	-88.25	8.1839	-47.69	4.4224	0	0	-86.06	7.9799
26	0	0	10.849	3.0518	0	0	-164.3	-46.23
27	-143.2	46.459	-6.430	2.0850	0	0	-22.09	7.1629
28	-1597.	66.216	-5.528	0.2291	0	0	599.37	-24.84
29	5323.3	104.13	-175.0	-3.423	0	0	-280.5	-5.487
30	0	0	0	0	0	0	267.02	28.990
31	-1746.	71.264	-5.484	0.2238	-233.3	9.5220	-208.3	8.5028
32	0	0	0	0	549.17	33.341	-645.9	-39.21
33	-1168.	34.195	-274.1	8.0262	-1616.	47.309	-151.5	4.4355
34	-360.4	67.612	214.82	-40.30	3058.4	-573.7	130.35	-24.45
35	223.34	16.520	-76.98	-5.694	1666.5	123.27	16.056	1.1877
36	0	0	0	0	235.95	62.465	308.26	81.608
37	421.26	98.166	-407.3	-94.91	894.75	208.50	-230.1	-53.62
38	487.62	335.64	-112.7	-77.59	302.30	208.08	120.33	82.831
39	1632.0	93.643	31.002	1.7788	1161.1	66.624	-18.14	-1.041
40	-712.4	323.98	483.81	-220.0	333.49	-151.6	-105.7	48.099
41	-1890.	53.401	-2021.	57.096	-27.56	0.7785	0	0
42	7162.4	327.56	-1668.	-76.30	-608.2	-27.81	0	0
44	0	0	-1302.	31.782	-4083.	99.619	0	0
45	-11.69	60.193	-6.580	33.878	0	0	0	0
46	1829.8	63.361	593.80	20.561	-901.5	-31.21	0	0
Tot	128.44	1.1931	1640.2	15.237	640.96	5.9544	4615.5	42.877

cont.

S.N.	EXP	(in %)	IMP	(in %)	-(g-h)	(in %)	Total	(in %)
8	-95.16	56.836	-412.9	246.61	-1732.	1034.6	-167.4	100
9	0	0	-36058	-336.8	-27878	-260.4	10703.	100
24	3322.7	199.27	-9651.	-578.7	-10020	-600.9	1667.4	100
43	0	0	0	0	119.33	3.5543	3357.5	100
1	-255.2	24.031	-5.057	0.4761	922.98	-86.89	-1062.	100
2	16.335	-135.9	9.3121	-77.50	4.5539	-37.90	-12.01	100
3	371.12	647.61	-113.9	-198.7	-162.1	-282.8	57.306	100
4	0.9774	-0.185	-15.42	2.9204	83.226	-15.75	-528.1	100
5	-9.105	1.2238	9.1062	-1 223	48.764	-6.554	-744.0	100
6	-63.68	-57.39	52.328	47.158	18.130	16.339	110.96	100
7	28.150	-204.0	-0.153	1.1115	2.2582	-16.37	-13.79	100
10	-550.5	185.83	-1.270	0.4288	307.48	-103.7	-296.2	100
11	12.845	-0.914	614.30	-43.71	-796.9	56.714	-1405.	100
12	-120.6	-11.68	4.7896	0.4638	117.43	11.373	1032.5	100
13	-1.049	0.0641	0	0	30.252	-1.847	-1637.	100
14	-3130.	106.17	-1441.	48.887	708.86	-24.03	-2948.	100
15	139.82	-72.71	24.623	-12.80	164.07	-85.32	-192.2	100
16	126.24	4.9601	40.029	1.5727	-22.74	-0.893	2545.2	100
17	-53.92	332.06	47.734	-293.9	-15.52	95.605	-16.23	100
18	-176.5	-43.41	53.280	13.101	622.34	153.03	406.67	100
19	-40.37	5.3457	17.325	-2.294	-63.57	8.4179	-755.2	100
20	-68.85	-10.75	-437.7	-68.40	-486.5	-76.03	639.92	100
21	-67.17	33.584	13.430	-6.714	249.44	-124.7	-200.0	100
22	590.17	56.675	26.894	2.5827	1.9531	0.1875	1041.3	100
23	-14.63	-14.36	-211.7	-207.9	-113.7	-111.7	101.83	100
25	-319.7	29.650	408.79	-37.90	-127.8	11.857	-1078.	100
26	1.4988	0.4216	-1994.	-561.0	-1486.	-418.2	355.50	100
27	140.21	-45.46	-22.87	7.4151	-299.6	97.169	-308.4	100
28	-253.6	10.510	860.87	-35.67	-294.5	12.206	-2412.	100
29	2313.3	45.253	917.38	17.945	-1151.	-22.53	5111.9	100
30	-35.70	-3.876	-1363.	-148.0	-674.0	-73.18	921.06	100
31	-64.21	2.6208	49.924	-2.037	-142.8	5.8283	-2450.	100
32	-1506.	-91.43	-7921.	-480.8	-4671.	-283.5	1647.1	100
33	-1070.	31.348	-1517.	44.424	-652.7	19.108	-3416.	100
34	154.52	-28.98	3009.0	-564.4	-721.7	135.40	-533.0	100
35	37.836	2.7987	482.30	35.676	-32.66	-2.416	1351.8	100
36	-133.6	-35.37	116.73	30.904	83.890	22.208	377.73	100
37	-26.52	-6.181	248.16	57.828	25.266	5.8878	429.12	100
38	24.997	17.206	481.32	331.31	-195.9	-134.8	145.27	100
39	174.23	9.9974	1117.1	64.099	-120.3	-6.903	1742.8	100
40	90.553	-41.18	760.48	-345.8	450.90	-205.0	-219.8	100
41	-353.5	9.9834	0	0	752.76	-21.25	-3540.	100
42	1455.3	66.559	5007.0	228.98	852.43	38.984	2186.5	100
44	0	0	0	0	1287.0	-31.40	-4098.	100
45	4.6014	-23.69	10.286	-52.95	4.5334	-23.34	-19.42	100
46	711.97	24.653	529.99	18.352	1183.9	40.994	2887.9	100
Tot	1305.8	12.131	-46256	-429.7	-43823	-407.1	10764.	100

Note 1. The import component should be deducted from the total.
2. For Sector name see Table 3.1.

the sectors which caused a reduction in energy use due to the consumption demand were rail transport(41), other food and beverages(14), other non-metalic mineral products(31), synthetic fiber and resin(28), coal & lignite(8), non-ferrous metal(33), construction(44) etc. whereas the reverse trend was experienced in sectors like other transport services(42), other chemicals(29), electricity(43), art silk and synthetic fiber(16), communication & electronic equipments(39), sugar(12), etc. Here it is to be noted that in the sector woolen textiles(17) the demand had changed to such an extent i.e.1003% that it offset the increase in energy requirement to a great extent.

The effect of composition of final demand due to change in investment level showed a decline in the energy requirements in sectors like iron & steel(32), other chemicals(29), other manufacturing(40), non-electrical machinery(34), fertiliser(26), other non-metalic minerals(31) cotton textiles(15) etc. while on the other hand, in sectors like coal & lignite(8), crude oil & N.gas(9), cereals(1), synthetic fiber & resin(28), rail equipments(36), cement(30) etc. the effect had positively increased the energy requirements.

During 1979-80 to 1991-92 there were 23 sectors where the export helped in reducing the energy use, the important among them being other food and beverages(14), iron & steel(32), non-ferrous metals(33), iron ore(10), rail transport(41) etc. As evident from the Table 5.9, in sector like petroleum products(24), other chemicals(29), other transport services(42), other services(46) rubber products(22), tea & coffee(3) etc. the export caused an increase in energy use. On the other hand the important sectors in changing the energy requirements due to imports were crude oil & n.gas(9), petroleum products(24), iron & steel(32), fertiliser(26), other food and beverages(14), cement(30), non-electrical machineries(34), other transport equipments(38), electronics and communication equipments(39), other manufacturings(40), other transport services(42), and other services(46).

5.4. Summary.

This chapter employed Indian I-O tables to analyse changes in the primary energy requirements in the Indian economy over the period 1979-80 to 1991-92 and decomposed energy use changes into different sources of change. The changes in energy use were factored into the effects of change in I-O coefficients(i.e. technology), changes in the final demand, changes due to the growth of the economy and change in the interaction of final demand and I-O coefficient changes. Further, the contribution of the individual final demand categories to the energy uses were also analysed. The total period 1979-80 to 1991-92 was divided into three sub-periods viz; 1979-80 to 1984-85, 1984-85 to 1989-90 and 1989-90 to 1991-92. The above analysis was conducted for the three sub-periods as well as the entire period under study thus giving an insight to both the short and long term aspects.

The results of this chapter which analysed the SDA of energy use changes showed that over the period 1979-80 to 1991-92 the primary energy uses had changed by 100211.1 Ttoe from 70971.23 Ttoe in 1979-80 to 171182.3 Ttoe in 1991-92. Due to changes in the level of final demand the energy use change increased by 71421.29 Ttoe while the increase in energy uses due to changes in the composition of final demand, changes in I-O coefficients and the interaction effects were 10764.57 Ttoe, 11588.27 Ttoe, 6436.96 Ttoe respectively. In terms of percentages the changes were 100.6%, 15.16%, 16.23%, and 9.06% of the initial level of energy use.

The average growth effect was clearly the most significant factor affecting energy use in the Indian economy. This factor alone accounted for 71.27% of the total increase in energy use during 1979-80 to 1991-92. That is "ceteris peribus" the change in level of output would have changed the energy requirement by 71421.29 Ttoe. This effect was highly significant for sectors like crude oil & n.gas, electricity, cereals, other crops, animal husbandry, sugar, other food and beverages, cotton textiles, other

textiles, other non-metalic mineral products, non-ferrous metals, non-electrical machineries, electrical machineries, motor vehicles, other non-manufacturings, rail transport services, construction, other services. This explains that had the final demand of these sectors been growing at the growth rate these sectors would have contributed significantly to energy use changes during the entire period covered in this study. But in reality, the final demand of these sectors grew much below average as reflected by the negative impacts due to this on some sectors, that is , the effects of changes in the composition of final demand helped in reducing the energy use in some sectors like cereals, other crops, animal husbandry, other minerals, khandasari & gur, other food and beverages, wood and wood products, coal tar products, synthetic fiber and resin, other non-metalic mineral products, non-ferrous metals, and construction.

The effects of technical change also had a relatively modest impact (11.56%) on the change in the energy uses during the same period 1979-80 to 1991-92. Due to this effect there was a decline in energy uses of sectors like iron ore, sugar, other food and beverages, woolen textiles, wood & wood products, fertiliser, pesticides, electrical machineries, rail equipments, motor vehicles, electronics & communication, rail transport services, other transport services, electricity, construction, other services. This reflects a substitution of technology with less intensity and high efficient technology. On the other hand technical development increased the energy requirement of sectors like cereals, other crops, animal husbandry, fishing, other minerals, cotton textiles, rubber products, non-electrical machineries, other transport equipments, other manufacturings, and communication.

The interaction factor in the total change in output during 1979-80 to 1991-92 was 6.42%. The contribution of this component of output growth showed the amount by which the contribution of the other three components would have been different had this factor not been separated out.

These trends as witnessed for the total period 1979-80 to 1991-92 were also observed for the three sub-periods but with some fluctuations. Finally, the results of the analysis of different final demand categories showed that over the period the energy use changes in Indian economy was largely due to the growth in consumption(mainly private) demand and investment demand.

In the next chapter we deal with the empirical analysis of the cost structure in the Indian economy treating energy as a basic primary input.

CHAPTER 6

SHARE OF ENERGY IN COST STRUCTURE

The Input-Output model has been used in structural decomposition analysis(SDA) of energy by a number of economists. These studies concentrated on the impact of, changes of energy coefficients and/or, changes in input-output coefficient (technology),and/or changes in the composition of final demand on the energy use of particular industries. Analysis of energy as basic input and change in prices of primary inputs(value added) has been given considerably less attention. However production for the needs of final demand, the use of primary inputs by industries in terms of constant prices and the role of the cost of using primary inputs in the formation of the cost of production of final demand are each closely related to the other(Forsell,1988).

In this chapter we treat energy as a basic primary input along with the labor and capital and study the cost share of energy in the total cost of different sectors of the Indian economy over the period of 1979-80 to 1991-92. There are, however, very few studies dealing with the aspect of energy analysis. Once the share is determined, then we made an attempt to decompose the change in share between two different periods into changes due to technological change, and/or changes due to change in primary inputs including energy, and/or changes due to both the change in technology and primary inputs(value added). Studies like Karasz(1992) and Thomas(1982) give the basic model in the I-O framework within which such analysis of cost shares can be conducted.

This chapter has been divided into three sections. The methodology used in the analysis of cost shares and changes of energy as a primary input is presented in the section 6.1. In the

section 6.2 energy(cost) share for the Indian economy over the period 1979-80 to 1991-92 are measured and explained, while in section 6.3 we made an attempt to decompose the change in energy cost between two periods into the change in the level of value added(growth of value added effect), and/or change in composition of energy cost, and/or change in technology, and/or their interaction factors.And finally, section 6.4 presents an overview of this chapter.

6.1. Methodology.

In this chapter we propose to analyse the share of energy as input over the years 1979-80 to 1991-92 and then to decompose the changes in energy cost of output of different sectors of the Indian economy over the same period into different sources, viz; changes due to change in technology, changes due to change in value added which includes energy as an input,and/or interaction effects of value added and technology. For identifying and measuring the share of energy and cost changes we have used the Karasz(1992) technique along with Thomas(1982) with some modifications. The methodology is described in the following paragraph. Costs/prices are examined columnwise in the I-O framework as explained in chapter 2. The basic equation for the price model, which describes the whole hierarchy of interindustrial relationship is given by the following cost equation:

$$z(t) = eZ(t) + h(t) \qquad \text{.............(6.1)}$$

and identities

$$z(t) = p(t)x(t) \qquad \text{.............(6.2)}$$

$$eZ(t) = p(t)X(t) \qquad \text{.............(6.3)}$$

whereby $x(t) = x(t)\ I$

where $z(t)$ is the vector of production expressed in current prices, $x(t)$ is the production expressed in constant prices, $Z(t)$ is the matrix of intermediate inputs expressed in current prices, $X(t)$ is the matrix of intermediate inputs expressed in constant

prices, $h(t)$ is the vector of value added expressed in current prices, $p(t)$ is the vector of price indices. e is the unit vector, I is the unit matrix and t is the time.

Substituting eq(6.2) and (6.3) into (6.1) and rearranging we obtain the equation of the price model:

$$p(t)x(t) = p(t)X(t) + V(t)$$
$$\Rightarrow p(t) = v(t)(I-A)^{-1} \quad \text{.............. (6.4)}$$

where $V(t)$ is the vector of value added in current prices, $v(t)$ is the vector of value added income per unit of production in constant prices. And A is the matrix of input coefficients(technological coefficients) expressed in constant prices.

Hence equation 6.4 shows that the price in sector i is dependent on the structure of intermediate consumption per unit of final demand in this sector and on value added and production created in individual sectors. The intensity of dependence of price on income and production of individual sectors is quite variable. For instance, the price of agriculture production is more dependent on income and production of chemical industries than some other producing industries.

Now in order to evaluate the impact from the cost change of energy, the energy sectors are treated as exogenous sectors and put into the primary input groups. Consequently the equation is changed into

$$P = (V + E^k)(I-A^{ne})^{-1} \quad \text{.................................... (6.5)}$$

Where E^k= is the direct energy input coefficient for each sector by fuel type k

A^{ne} = input coefficient matrix excluding energy sectors

V = value added matrix excluding the energy sectors.

If we assume that the cost changes of each sector could be totally transferred and the annual production of each sector is given, then we can evaluate the whole sale price change on the economic system due to the cost change of energy. Based on which, we can formulate the energy pricing strategies.

For the present study, changes in output costs are examined from the demand perspective. The perspective tells us the effect of output costs that result from the changes in the demand of the products of one or more sectors. Suppose the final demand of the output of one or more sectors increases. To meet this increase in final demand, sectors would have to increase their outputs which may be required either directly or indirectly to satisfy the increase in final demand. In this chapter first, we made an attempt to calculate the share of energy content in the cost/prices of different sectors by using the above mentioned methodology.

In this chapter we want to observe how much and in what direction these shares have changed between the initial year and the terminal year under study in the Indian economy. An increase or decrease in costs in a given sector is determined by the effects of changes in the complex coefficients of the sectors and/or changes in the value added in all the sectors. The basis for a deep understanding and investigation of these effects is determined by a separation of the cost changes between the influence of changes in the coefficients and the influence of change in value added. Any change in input prices or quantities(both primary and energy input) or both resulting from this would effect the costs of output of different sectors, thus the right hand side of the equation 6.5 indicates how much of each primary and energy input in value terms is directly and indirectly included in one unit of final demand for each sector. To put it differently, it shows the cost share of primary & energy inputs per unit of final demand. An observation in this direction has been made in this chapter.

If in equation 6.5 we denote $(I-A^{ne})^{-1}$ by R' and V' by $(V^e + V^{ne})$ where V^e is the energy component and V^{ne} is non-energy component of value added, then the difference in energy cost shares between the initial year(o) and the terminal year(t) can be written as follows:

$$dC = V^e_t R'_t - V^e_o R'_o \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6.6)$$

where V^e_t = mxn matrix of value added shares in the year t consisting of m types of energy inputs

R'_t = (n-m)x(n-m) inverse matrix of $(I-A^{ne})$ coefficient in year t

o,t = stand for initial year and terminal year respectively.

Hence equation 6.6 shows that the change in cost shares is a function of changes in value added and/or change in technology and/or both.

Usually the difference in cost shares of primary inputs per unit of final demand between the initial year(o) and the terminal year(t) are obtained as follows. An increase or decrease in costs in a given sector is determined by the effects of change in the I-O coefficients of the sectors , and/or changes in the value added per unit of output in all sectors. The starting point of this decomposition is given by the following relation:

$$dC(dP) = (V^e_t - V^e_o)\ R'_t + V^e_o(R'_t - R'_o)$$

$$\text{or,} \quad dC(dP) = V^e_t(R'_t - R'_o) + R'_o(V^e_t - V^e_o) \quad \ldots\ldots\ldots\ldots\ldots\ldots (6.7)$$

where $dC(dP) = P_t - P_o$, and V^e_t, V^e_o, R'_t, R'_o represents the value added an technology respectively in the terminal year and the initial year.

In the above two formulations, the first term on the right hand side shows the effect of technical change in the cost/price

change of the economy, which includes the direct and indirect effect of a particular sector. The second term indicates how much of the difference in cost/price is due to change in value added between the initial year and the terminal year. However, in this case also, the above formulations suffer from the weighting problem as discussed in the previous chapters. As the weights used for each of the effects are different in the two equations mentioned above, a unique solution for each effect is not possible. In order to overcome this drawback we can modify the equations by weighting both the effects by base year weights or the terminal year weights as follows:

$$dc = V_t^e R_t' - V_o^e R_o' = V_t^e R_t' - V_t^e R_o' + V_t^e R_o' - V_o^e R_o'$$

$$= (V_t^e - V_o^e) R_t' + V_o^e (R_t' - R_o')$$

$$= (V_t^e - V_o^e) R_t' - (V_t^e - V_o^e) R_o' + (V_t^e - V_o^e) R_o' + V_o^e (R_t' - R_o')$$

$$= (V_t^e - V_o^e)(R_t' - R_o') + (V_t^e - V_o^e) R_o' + V_o^e (R_t' - R_o')$$

or it may also be written as

$$= (V_t^e - V_o^e)(R_t' - R_o') + (V_t^e - V_o^e) R_t' + V_t^e (R_t' - R_o') \qquad \text{.........\ ..(6.8)}$$

Though the above formulations is used for an economy by some economists like Karasz(1992), there is no such attempt to study the share of energy in the cost structure and the decomposition of such cost change. The basic difference between the model which we have adopted and that of the Karasz(1992) is that while in Karasz(1992) the value added component is in current prices, in our model it is in constant prices like the transaction vectors. The basic reason behind this is that, along with the intermediate and final demand, the price of the value added also changes over

time. In other words the value of, say, labour in period t is not same as that of the period o. Hence if the value added component of the estimated equation is not brought to the constant prices then the spurious price increase will effect the component of the value added change to a great extent.

According to the methodology we have adopted for the purpose of our study (which is an extension of the above formulation with some modifications) the components of changes in the cost shares of energy and primary inputs between the initial year and the terminal year under study are derived as follows:

If we define $\alpha = V_t^e / V_o^e$ be the expansion rate of value added between any the initial year o and the terminal year t, then the change in cost may be decomposed into

$$dc = V_t^e R_t' - V_o^e R_o' = V_t^e R_t' - V_t^e R_o' + V_t^e R_o' - V_o^e R_o'$$

$$= V_t^e R_t' - V_t^e R_o' + V_t^e R_o' - \alpha V_o^e R_o' + \alpha V_o^e R_o' - V_o^e R_o'$$

$$= V_t^e (R_t' - R_o') + (V_t^e - \alpha V_o^e) R_o' + V_o^e (\alpha - 1) R_o'$$

$$= V_t^e (R_t' - R_o') - V_o^e (R_t' - R_o') + V_o^e (R_t' - R_o') + (V_t^e - \alpha V_o^e) R_o'$$

$$+ V_o^e (\alpha - 1) R_o'$$

$$= (V_t^e - V_o^e)(R_t' - R_o') + V_o^e (R_t' - R_o') + (V_t^e - \alpha V_o^e) R_o' + V_o^e (\alpha - 1) R_o' \qquad \text{.....................(6.9)}$$

We summarize the hierarchical structure of the estimation equations of the energy cost component change, we use in our analysis, in the Table 6.1.

Table 6.1. The Components of SDA of the Energy Cost Changes.

Energy Component in the initial Year		$V^e_o R'_o$
(i)	Growth of V.Added Effect	$V^e_o(\alpha - 1)R'_o$
(ii)	Composition of V.Added Effect.	$(V^e_t - \alpha V^e_o)R'_o$
(iii)	Technological Effect.	$V^e_o(R'_t - R'_o)$
(iv)	Interaction Effect.	$(V^e_t - V^e_o)(R'_t - R'_o)$
(v)	Total Effect.	$V^e_t R'_t - V^e_o R'_o$
Energy Component of the terminal Year.		$V^e_t R'_t$

The first three components in the Table 6.1 show the main effects on cost share changes. They show the effects of changes in growth of value added, effects of changes in the composition of value added, effect of changes in I-O coefficients on changes in cost shares between the ınitial year and terminal year respectively. Unlike the conventional formulation, these three effects are weighted by initial year values showing the separate effects with respect to the base year. On doing this reformulation we can able to get the interaction effects which were implicitly included in the main effects thereby either overestimating or underestimating their values. The basic advantage of our formulation over the existing formualtions is, it ables to give us the exact shares of the composition of primary energy inputs and the growth of energy inputs besides the technological effect on the total cost share change between the initial year and the terminal year.

The effects of the changes in the composition of energy inputs and the intermediate input coefficients show to what extent technical development has changed cost shares. In other words

this shows the interaction effect of the changes in the composition of energy input and the change in technology. That is, for sector i this term expresses the amount of the cost changes in sector that i is given by value added change in other sectors and the I-O coefficient change in sector i that are mutually connected.

The second component in the Table 6.1 shows the effects of growth in value added on cost share changes between the initial year and the terminal year. This effect indicates how much more (or less) the cost would have increased (or decreased) if the value added would have increased at the same rate over all the sectors of the economy, technology being remain the same as the initial year. However, all the sectors of an economy do not grow at the average rate. While some sectors grow at a higher rate then the average growth factor, some other sectors grow at a level much lower than the growth rate. This problem is dealt by the third factor which shows the contribution or effect of the composition of the energy input. The sum of the second and the third component give the total value added(energy) effect on the energy share change. And finally, the last term shows the effect of the technology change or the change in the I-O coefficients.

Thus changes in cost shares of energy over a particular period are the result of four different effects; average growth of value added, change in the composition of value added, changes in the technology, and the interaction effect. The sum of all the four effects give us the total difference between the initial year and the terminal year of a given time period.

Concerning the interpretation, both the sign and the absolute value of individual parts of the decomposition given in equation 6.9 are important. In the case of a positive sign the influence is to increase cost, and in the case of a negative sign the influence is to decrease the cost. The size of the influence is directly proportional to the absolute value of the decomposition part. For analytical point of view it is useful to express

equation 6.9 in percentage terms along with the absolute value where dc = 100%.

In the next section we shall first study the share of energy as a primary input in the cost structure of all the sectors of the economy for the four years for which the Input-Output tables are available. The second objective of decomposition of energy cost share changes is dealt in the next subsection of 6.3 of this chapter.

6.2. The Energy Cost Shares.

The components of changes in costs of Indian economy are examined for the period 1979-80 to 1991-92. The entire period is divided, as in the previous chapters, into three sub-periods which are merely dictated by the availability of input-output data. In this section an attempt has been made to analyse the energy share of different sectors for the four years 1979-80, 1984-85, 1989-90, and 1991-92. By share of energy we mean the share of energy as a primary input to the total value added. In otherwords this shows the direct and indirect energy required as primary inputs to produce one unit of goods and services of different sectors of an economy. The energy cost of all sectors for the four years under study are shown in the Tables 6.2, 6.3, 6.4 and 6.5 respectively. These tables show the actual contribution of four energy sources as well as the total energy used. While in this section we are dealing with the share of energy to total cost, in the next section we analyse the sources of this change in cost over the whole period of 1979-80 to 1991-92 and the three sub-periods 1979-80 to 1984-85, 1984-85 to 1989-90, and 1989-90 to 1991-92.

Table 6.2 gives the share of energy cost of the total cost for the year 1979-80. It is clear from the Table 6.2 that the share of energy in primary sectors except tea and coffee(3) were very low. For instance the share of energy in the total cost of cereals(1) was only 3.9% whereas in fiber crops(2) it was 2.4%. So

Table 6.2 Share of Energy Cost to total Cost in 1979-80.

S.No.	Coal	Oil & N.Gas	Petroleum	Electricity	Total
1	0.003860	0.000262	0.021680	0.014137	0.039940
2	0.001602	0.000168	0.016141	0.006831	0.024743
3	0.011256	0.000636	0.029410	0.034520	0.075823
4	0.001032	0.000051	0.005092	0.003714	0.009890
5	0.001496	0.000524	0.006159	0.005609	0.013790
6	0.001485	0.000208	0.006869	0.002114	0.010678
7	0.000640	0.000245	0.015186	0.003023	0.019095
10	0.031235	0.001012	0.142652	0.054293	0.229193
11	0.025421	0.000343	0.101366	0.041067	0.168199
12	0.009647	0.001056	0.026361	0.039805	0.076870
13	0.008780	0.001069	0.014189	0.013627	0.037666
14	0.010764	0.004694	0.027372	0.025349	0.068180
15	0.005926	0.004941	0.034702	0.036027	0.081598
16	0.008235	0.008209	0.010515	0.013271	0.040232
17	0.021697	0.007249	0.027489	0.032856	0.089292
18	0.008597	0.003989	0.026690	0.024788	0.064065
19	0.005783	0.000820	0.069224	0.042264	0.118093
20	0.040310	0.001209	0.029673	0.056080	0.127273
21	0.006805	0.001789	0.019823	0.020338	0.048757
22	0.019385	0.001882	0.038774	0.032692	0.092735
23	0.009385	0.008597	0.025550	0.031409	0.074943
25	0.483606	0.000529	0.053773	0.020659	0.558568
26	0.031363	0.000883	0.040035	0.093933	0.166215
27	0.018062	0.001426	0.032274	0.035238	0.087002
28	0.020472	0.024423	0.023186	0.029830	0.097912
29	0.027861	0.001608	0.037142	0.043582	0.110195
30	0.139472	0.000825	0.075030	0.107568	0.322896
31	0.075581	0.035702	0.045115	0.029226	0.185626
32	0.064174	0.001630	0.071039	0.046035	0.182880
33	0.023065	0.004408	0.041308	0.045619	0.114401
34	0.013794	0.003434	0.030932	0.029658	0.077819
35	0.013963	0.007759	0.027803	0.029271	0.078797
36	0.026265	0.001708	0.048750	0.049008	0.125732
37	0.013807	0.001733	0.039502	0.031041	0.086085
38	0.011147	0.015084	0.032233	0.023167	0.081632
39	0.009846	0.002425	0.024508	0.024850	0.061630
40	0.010367	0.002361	0.020451	0.017345	0.050525
41	0.054803	0.000769	0.074270	0.022724	0.152568
42	0.003858	0.000976	0.157542	0.013843	0.176221
44	0.024744	0.004467	0.031528	0.028327	0.089068
45	0.001245	0.000165	0.006771	0.004425	0.012607
46	0.004063	0.001097	0.011546	0.024929	0.041636

Note: For name of the Sectors see Table 3.1.

was the case for other primary sectors like other crops(4), animal husbandry(5), forestry & logging(6), and fishing(7). As far as the mining and querying are concerned the share of energy was very high for iron ore(9), and other minerals(10). As is evident from the table that while for the food product sectors(12, 13, 14), textiles (15, 16, 17, 18), the share of energy in the cost structure was less than 10%, while in most of the other manufacturing sectors the energy is accounted for a higher share. The sectors with high energy cost during 1979-80 were coal tar products(25), cement(30), other non-metalic minerals(31), iron & steel(32), fertiliser(26), and rail equipments(36). The share of energy in transport sectors was also very high, the respective shares for railways(41) and other transports(42) being 15% and 17%. Similar analysis for the individual energy components viz; coal, oil, petroleum product, and electricity can also be made from the tables.

The share of total energy along with the individual energy sources for the year 1984-85 is presented in the Table 6.3. During this year also the primary sectors remained the low energy cost using sectors. The respective share of cereals(1), fiber crops(2), tea & coffee(3), other crops(4), animal husbandry(5), fishing(7) and forest & logging(6) were 6.2%, 5.2%, 2.9%, 2.7%, 2.2%, 1.8%, and 1.3%. However, compared to the previous year of 1979-80 in all the sectors except tea & coffee(3) the energy share had increased. A decline in energy share had also been experienced in the mining and querying compared to 1979-80. Though in this period also energy share in manufacturing sectors remained high and some sectors experienced an increase in their comparative share as compared to the previous year. The sectors with high energy cost during 1984-85 were; fertiliser(26) with 46.3%, coal tar products(25) with 44.3%, cement(30) with 25.6%, non-ferrous metals(33) with 23.6%, synthetic fiber & resin(28) with 22.9%. As far as the transport sectors were concerned, the share had increased to 17.6% and 23.2% in rail transport(41), other transport(42) from 15.2% and 17.5% during the period.

Table 6.3 Share of Energy Cost to total Cost in 1984-85.

S.No.	Coal	Oil & N.Gas	Petroleum	Electricity	Total
1	0.002160	0.002341	0.042692	0.015614	0.062808
2	0.001884	0.002008	0.030440	0.018265	0.052598
3	0.001827	0.007079	0.013536	0.007394	0.029837
4	0.000999	0.001366	0.018746	0.006856	0.027968
5	0.001063	0.000724	0.013761	0.007007	0.022557
6	0.001531	0.000015	0.007522	0.004589	0.013658
7	0.000303	0.000010	0.015524	0.002353	0.018192
10	0.000801	0.000013	0.082616	0.018957	0.102388
11	0.000572	0.000011	0.029429	0.033629	0.063643
12	0.002300	0.000894	0.031117	0.016820	0.051132
13	0.002328	0.000720	0.046837	0.023280	0.073167
14	0.002359	0.001206	0.024560	0.019336	0.047463
15	0.003827	0.000683	0.024406	0.065409	0.094326
16	0.005111	0.000272	0.038444	0.084439	0.128268
17	0.004565	0.000387	0.022583	0.063123	0.090658
18	0.001979	0.000286	0.014804	0.034393	0.051464
19	0.003889	0.000153	0.017823	0.048474	0.070341
20	0.010206	0.000230	0.037924	0.106895	0.155257
21	0.001930	0.000304	0.019075	0.021661	0.042971
22	0.003540	0.000305	0.038014	0.049868	0.091728
23	0.002978	0.000168	0.104341	0.060991	0.168479
25	0.361129	0.000096	0.037218	0.044794	0.443238
26	0.034702	0.056383	0.283277	0.089511	0.463874
27	0.003416	0.000252	0.022948	0.046605	0.073222
28	0.007051	0.000386	0.129203	0.093321	0.229963
29	0.005421	0.000439	0.035439	0.079785	0.121085
30	0.089617	0.000211	0.043122	0.123812	0.256764
31	0.020296	0.000253	0.042843	0.060948	0.124342
32	0.031549	0.000140	0.022926	0.104895	0.159511
33	0.012830	0.000152	0.046741	0.176930	0.236654
34	0.012654	0.000117	0.015572	0.065428	0.093773
35	0.008492	0.000138	0.018086	0.056606	0.083324
36	0.014699	0.000128	0.038447	0.082342	0.135617
37	0.010062	0.000131	0.039442	0.056055	0.105691
38	0.007728	0.000131	0.035138	0.053602	0.096600
39	0.005021	0.000138	0.021447	0.041059	0.067666
40	0.008483	0.000093	0.017548	0.042503	0.068629
41	0.045696	0.000060	0.079470	0.051286	0.176514
42	0.000664	0.000033	0.227267	0.005002	0.232967
44	0.015214	0.000179	0.027212	0.032245	0.074851
45	0.001320	0.000014	0.019037	0.011789	0.032161
46	0.002491	0.000356	0.012573	0.012590	0.028012

Note: For name of the Sectors see Table 3.1.

Table 6.4 Share of Energy Cost to total Cost in 1989-90.

S.No.	Coal	Oil & N.Gas	Petroleum	Electricity	Total
1	0.003970	0.001603	0.034537	0.027336	0.067448
2	0.004854	0.002610	0.051818	0.034172	0.093455
3	0.001112	0.000474	0.006092	0.003311	0.010990
4	0.002374	0.000992	0.027629	0.013848	0.044845
5	0.001681	0.000461	0.014679	0.008332	0.025154
6	0.000395	0.000003	0.010600	0.001614	0.012613
7	0.000302	0.000007	0.013331	0.001043	0.014685
10	0.002484	0.000016	0.099060	0.075424	0.176986
11	0.001768	0.000012	0.045239	0.041893	0.088913
12	0.006487	0.000477	0.034067	0.016857	0.057889
13	0.010636	0.000321	0.071822	0.030232	0.113013
14	0.008794	0.000658	0.031760	0.021066	0.062279
15	0.012753	0.000817	0.044375	0.052034	0.109981
16	0.011420	0.000128	0.043465	0.122438	0.177453
17	0.014113	0.000343	0.033424	0.036847	0.084728
18	0.007231	0.000253	0.025727	0.030470	0.063682
19	0.002349	0.000021	0.014640	0.009427	0.026440
20	0.032923	0.000127	0.035664	0.061954	0.130669
21	0.005347	0.000150	0.025993	0.020184	0.051675
22	0.007273	0.000183	0.039177	0.028942	0.075577
23	0.006687	0.000076	0.042223	0.046722	0.095711
25	0.362736	0.000036	0.046164	0.043197	0.452135
26	0.031695	0.025911	0.211867	0.097797	0.367272
27	0.005679	0.000095	0.037403	0.036655	0.079835
28	0.020390	0.000185	0.085369	0.064020	0.169966
29	0.011630	0.000388	0.069605	0.053064	0.134688
30	0.082934	0.000041	0.028787	0.081717	0.193480
31	0.056372	0.000859	0.089817	0.036757	0.183806
32	0.059243	0.000365	0.052649	0.060156	0.172414
33	0.010695	0.000554	0.086173	0.111380	0.208803
34	0.017516	0.000167	0.033133	0.036553	0.087371
35	0.009043	0.000198	0.032763	0.033290	0.075296
36	0.009641	0.000192	0.032681	0.031246	0.073762
37	0.016077	0.000149	0.040288	0.038948	0.095463
38	0.009241	0.000067	0.024466	0.021132	0.054907
39	0.004209	0.000216	0.015674	0.018978	0.039079
40	0.015056	0.000103	0.028326	0.036062	0.079549
41	0.023877	0.000064	0.064707	0.043178	0.131828
42	0.002734	0.000026	0.143391	0.013040	0.159192
44	0.021334	0.000128	0.023980	0.033582	0.079025
45	0.001696	0.000015	0.006526	0.009778	0.018016
46	0.003064	0.000037	0.008490	0.011029	0.022622

Note: For name of the Sectors see Table 3.1.

The analysis of energy share of energy cost as a primary input for the third period 1989-90 is shown in the Table 6.4. During this period the most important sectors were coal tar products(25), fertiliser(26), and non-ferrous metals(33), the respective shares of these sectors being 45.2%, 36.7%, and 20.8%. The other sectors where shares fluctuated between 10 to 20% were other minerals(10), khandasari & boora(13), cotton textiles(15), woolen textiles(16), synthetic fiber & resin(28), cement(30), other non-metalic minerals(31), iron & steel(32), and other transport(42). The remaining manufacturing sectors and the primary sectors(1, 2, 3, 4, 5, 6, 7) were the sectors with low energy component in their total cost . The shares for these sectors were usually less than 10% of the total costs.

The Table 6.5 gives the detailed picture of the individual energy share and the total energy shares of all the sectors of the Indian economy for the year 1991-92. During this period also like the previous periods, the sectors with high energy share were plastic products(23), coal tar products(25), fertiliser(26), synthetic fiber & resin(28), iron & steel(32), non-ferrous metals(33), whose shares were more than 20% of the total cost. Hence compared to the previous year, there were two additions to the list of high energy sectors namely synthetic fiber & resin(28) and iron & steel(32). The respective shares of these sectors were 20.3%, 37.5%, 22.5%, 26.6%, 21.7%, 27.7%, and 25.3%. On the other hand other minerals(10), cotton textiles(15), woolen textiles(16), paper & paper products(20), other chemicals(29), cement(30), other non-metalic mineral(31), non-electrical machineries(34), other transport equipments(38), and rail transport(41) were those sectors whose shares fluctuated between 10% to 20% of the total cost. For the remaining sectors the energy costs accounted for less than 10%. As usual in this period also the primary sectors were with very low energy share.

For further scanning the trend in the energy share in the total costs, we calculated the percentage changes of energy shares as follows;

Table 6.5 Share of Energy Cost to total Cost in 1991-92.

S.No.	Coal	Oil & N.Gas	Petroleum	Electricity	Total
1	0.003580	0.002071	0.044356	0.038832	0.088841
2	0.002475	0.002137	0.035939	0.026171	0.066724
3	0.001165	0.000335	0.005243	0.003828	0.010573
4	0.001230	0.000828	0.017522	0.009561	0.029142
5	0.001340	0.000389	0.012029	0.008278	0.022038
6	0.000317	0.000005	0.010772	0.002233	0.013328
7	0.000689	0.000023	0.031865	0.002683	0.035262
10	0.001407	0.000033	0.074671	0.056543	0.132656
11	0.000965	0.000020	0.028450	0.029048	0.058485
12	0.004049	0.000460	0.028582	0.015295	0.048387
13	0.006342	0.000274	0.055535	0.023955	0.086108
14	0.008980	0.000900	0.037309	0.027714	0.074904
15	0.011613	0.000358	0.043782	0.063520	0.119275
16	0.008363	0.000163	0.044379	0.078915	0.131821
17	0.010109	0.000404	0 033531	0.035937	0.079982
18	0.006517	0.000363	0.030393	0.035574	0.072848
19	0.001603	0.000028	0.013406	0.008999	0.024038
20	0.024470	0.000197	0.034709	0.060675	0.120052
21	0.004748	0.000168	0.029143	0.024813	0.058873
22	0.003719	0.000177	0 025751	0.018784	0.048433
23	0.014182	0.000753	0.097681	0.091243	0.203860
25	0.282971	0.003647	0.045294	0.043607	0.375521
26	0.014477	0.021324	0.126125	0.059941	0.221869
27	0.003677	0.000196	0.031911	0.030680	0.066466
28	0.024161	0.000472	0.139601	0.102715	0.266950
29	0.006909	0.000704	0.055736	0.041171	0.104521
30	0.041484	0.000064	0.022843	0.056060	0.120453
31	0.037117	0.001098	0.077109	0.033004	0.148330
32	0.068763	0.000843	0.067176	0.080967	0.217751
33	0.010707	0.001204	0.111825	0.153612	0.277349
34	0.019441	0.000338	0.037483	0.042919	0.100183
35	0.010342	0.000375	0.038520	0.039517	0.088756
36	0.002299	0.000065	0.006526	0.006550	0.015442
37	0.015576	0.000264	0.039322	0.039473	0.094636
38	0.017005	0.000263	0.045994	0.042530	0.105794
39	0.004896	0.000281	0.018271	0.020911	0.044361
40	0.011551	0.000209	0.024079	0.029879	0.065719
41	0.024186	0.000144	0.086997	0.048033	0.159361
42	0.003066	0.000053	0.201706	0.048512	0.253339
44	0.020489	0.000299	0.028420	0.039776	0.088985
45	0.002109	0.000039	0.013978	0.020480	0.036607
46	0.002061	0.000043	0.009704	0.012575	0.024384

Note: For name of the Sectors see Table 3.1.

$$PEC = \frac{EC_t - EC_{t-1}}{EC_{t-1}} \times 100$$

where EC_t is the share of energy cost at the time period t and EC_{t-1} the share of energy cost at the time period t-1.

As is evident from the Table 6.6 the share of energy to total value added in the primary agriculture sector was increasing over the years. The main reason behind such an increase is the energisation of agriculture over the years. The energy requirement in the agriculture sector and thus the share of energy to total value added had increased with increase in irrigated areas, replacement of the hand pumps by diesel and electric pumpsets, lowering of water tables and increase in the use of tractors. A similar increase in energy component was experienced in cotton textile sector because of the replacement of the handloom by the mills which were comparatively more energy intensive.

The results of the Table 6.6 showed that the Energy component in paper and paper products had declined substantially as in view of the growing demand, setting up of small units was encouraged upto the sixth the plan. Small units have comparatively low level of energy share due to high percentage of waste paper use and absence of soda recovery unit.

As far as the cement sector is concerned the share of the dry process which is overall energy efficient has increased over the years. Besides the specific energy consumption in cement manufacture had witnessed a gradual decline since 1980s as a result of technological improvements viz. adoption of vertical roller mills, high efficiency separators, high efficiency fans, variable speed systems etc.. As a result of the developments in the cement sector, the energy component had experienced a continuous decline over the whole period under study.

Table 6.6 Changes in Energy Cost Share Over the Years.

S.No.	1979-84	1984-89	1989-91	1979-91
1	57.25	7.386	31.71	122.4
2	112.5	77.67	-28.6	169.6
3	-60.6	-63.1	-3.79	-86.0
4	182.7	60.33	-35.0	194.6
5	63.57	11.51	-12.3	59.81
6	27.89	-7.64	5.665	24.81
7	-4.72	-19.2	140.1	84.66
10	-55.3	72.85	-25.0	-42.1
11	-62.1	39.70	-34.2	-65.2
12	-33.4	13.21	-16.4	-37.0
13	94.25	54.45	-23.8	128.6
14	-30.3	31.21	20.27	9.862
15	15.59	16.59	8.450	46.17
16	218.8	38.34	-25.7	227.6
17	1.529	-6.54	-5.60	-10.4
18	-19.6	23.73	14.39	13.70
19	-40.4	-62.4	-9.08	-79.6
20	21.98	-15.8	-8.12	-5.67
21	-11.8	20.25	13.92	20.74
22	-1.08	-17.6	-35.9	-47.7
23	124.8	-43.1	112.9	172.0
25	-20.6	2.007	-16.9	-32.7
26	179.0	-20.8	-39.5	33.48
27	-15.8	9.031	-16.7	-23.6
28	134.8	-26.0	57.06	172.6
29	9.882	11.23	-22.3	-5.14
30	-20.4	-24.6	-37.7	-62.6
31	-33.0	47.82	-19.3	-20.0
32	-12.7	8.088	26.29	19.06
33	106.8	-11.7	32.82	142.4
34	20.50	-6.82	14.66	28.73
35	5.744	-9.63	17.87	12.63
36	7.862	-45.6	-79.0	-87.7
37	22.77	-9.67	-0.86	9.932
38	18.33	-43.1	92.67	29.59
39	9.793	-42.2	13.51	-28.0
40	35.82	15.91	-17.3	30.07
41	15.69	-25.3	20.88	4.452
42	32.20	-31.6	59.14	43.76
44	-15.9	5.576	12.60	-0.09
45	155.0	-43.9	103.1	190.3
46	-32.7	-19.2	7.791	-41.4

Note: Figures are in percentage(%) terms.
For Sector Name See Table 3.1.

This exercise showed that there were only four sectors namely, tea and coffee(3), wood and wood products(19), rubber products(22), cement(30) where energy shares were continuously declining over the years, while there were other four sectors viz; woolen textiles(17), paper and paper products(20), fertiliser(26), pesticides(27), where share increased in the first sub-period but declined in the subsequent two sub-periods. On the other hand, there was only one sector i.e. cotton textiles(15) where share was increasing throughout the period while, for sectors like other food and beverages(14), other textiles(18), leather and leather products(21), iron & steel(32), construction(44) where energy share declined in the first period but increased in the subsequent two periods. Further, for sectors like fishing(6), and other services(46) the share had declined for the first two sub-periods but started increasing in the last subperiod i.e. 1989-90 to 1991-92. On the other hand, the reverse trend was experienced in fiber crops(2), other crops(4), animal husbandry(5), khandsari & boora(13), art silk and synthetic textiles(16), other chemicals(29), rail equipments(36), other manufacturings(40). The remaining sectors showed a fluctuation in their energy shares over the period under study.

6.3. Components of Changes in the Energy Cost.

Once the energy's share in the total cost has been calculated for the 42 non-energy producing sectors for the four years viz; 1979-80, 1984-85, 1989-90, and 1991-92, the second objective of this chapter is to examine the components of changes in energy cost of various sectors of the Indian economy for the period 1979-80 to 1991-92. The analysis was carried out for three sub-periods viz; 1979-80 to 1984-85, 1984-85 to 1989-90, and 1989-90 to 1991-92 and the whole period viz; 1979-80 to 1991-92. Decomposition of the sources of cost share changes for 1979-80 to 1984-85, for 1984-85 to 1989-90, for 1989- 90 to 1991-92 are shown in the Tables 6.7, 6.8, and 6.9, while the Table 6.10 shows the

different sources of cost shares change for the total period under study i.e 1979-80 to 1991-92. These tables show the actual contribution of different sources i.e the technological changes effect, value added effect, growth effect, composition of value added effect and interaction effects and their percentage contribution to the total energy share changes. The percentages figures across all sectors(rows) in the table should sum to 100. This section begins by analysing the results for 1979-80 to 1984-85 sub-period and then discusses for the other sub-periods and for the total period one by one.

Table 6.7 gives the sources of cost share change for the sub-period 1979-80 to 1984-85. During these years some sectors like fertiliser(26), non-ferrous metals(33), synthetic fiber & resin(28), plastic products(23), woolen textiles(16), other transport(42) experienced very high increase in their energy costs while sectors like iron ore(10), other minerals(11), sugar(12), tea & coffee(3), experienced a decline in their energy costs. Energy cost of fertiliser(26) increased by 157.83% in 1984-85 as compared to 1979-80 while that of non-ferrous metals(33) had increased by 97.84% over the same period, whereas in sectors like iron ore and other minerals the energy share had declined by 53.43% and 57.13% respectively. On the other hand primary sectors like cereals(1), fiber crops(2), fishing(7), cotton textiles(15), electrical machineries(35), electronics & communication equipments(39), had experienced a very small increase in energy costs compared to the base year 1979-80.

For almost all sectors the impetus to energy cost change came from the effects of growth in value added which are positive in real terms. This component shows how much the cost of different sectors would have changed if the factor prices had increased by the growth rate of value added. But in percentage terms the share of the effect were positive for sectors like cereals(1), fiber crops(2), tea & coffee(3), other crops(4), animal husbandry(5), forest & logging(6), khandsari & boora(13), cotton textiles(15), woolen textiles(16), paper & paper products(20), plastic

Table 6.7 Components of SDA of Energy cost changes during 1979-80 to 1984-85.

S N.	Energy Comp 79-80	Int Effect	in %	Tec Effect	in %	V.Added Effect	in %
1	0.040118	-0.01247	-61.6	-0.00769	-38.0	0.040413	199.6
2	0.023718	0.002252	8.281	0.005904	21.70	0.019043	70.01
3	0.059814	-0.04732	154.7	-0.03427	112.0	0.051022	-166.
4	0.009762	-0.00053	-3.08	0.000004	0.025	0.017797	103.0
5	0.013281	-0.00230	-26.0	0.001339	15.11	0.009833	110.9
6	0.010314	-0.00160	-50.1	-0.00221	-69.0	0.007033	219.1
7	0.018531	0.000048	-8.00	-0.00092	152.4	0.000270	-44.4
10	0.200860	-0.01175	10.95	-0.03911	36.45	-0.05643	52.59
11	0.140244	-0.00465	5.813	-0.00629	7.848	-0.06920	86.33
12	0.100396	-0.00173	3.513	-0.03136	63.41	-0.01635	33.07
13	0.045003	-0.00914	-37.6	-0.01479	-60.8	0.048269	198.4
14	0.066599	-0.01505	77.66	-0.01744	89.96	0.013111	-67.6
15	0.088563	-0.00463	-546.	-0.01503	-1771	0.020516	2418.
16	0.039371	-0.02710	-31.6	0.013288	15.50	0.099524	116.1
17	0.095689	-0.03867	201.2	-0.02495	129.8	0.044406	-231.
18	0.065210	-0.00810	50.40	-0.01359	84.56	0.005622	-34.9
19	0.107358	-0.02696	67.25	0.037697	-94.0	-0.05082	126.7
20	0.118462	-0.00389	-13.3	0.011546	39.60	0.021502	73.75
21	0.047111	-0.00852	160.2	-0.00883	166.0	0.012044	-226.
22	0.090777	-0.01991	269.1	-0.01635	220.9	0.028872	-390.
23	0.071645	-0.00972	-10.9	-0.00221	-2.48	0.101056	113.3
25	0.372533	-0.00808	31.00	0.049216	-188.	-0.06721	257.6
26	0.143588	0.012001	5.297	-0.00696	-3.07	0.221497	97.77
27	0.079521	-0.01834	149.6	-0.00867	70.80	0.014765	-120.
28	0.097002	-0.02153	-21.6	-0.01888	-18.9	0.140095	140.5
29	0.099786	-0.00663	-40.7	0.011244	69.03	0.011674	71.67
30	0.244630	-0.00904	55.50	0.014858	-91.1	-0.02211	135.6
31	0.160898	-0.00951	24.88	0.021891	-57.2	-0.05062	132.3
32	0.157888	-0.01686	587.6	0.042848	-1493	-0.02885	1005.
33	0.106398	0.002167	2.083	0.004108	3.948	0.097774	93.96
34	0.072470	-0.03088	-213.	0.029648	205.2	0.015682	108.5
35	0.075487	-0.02620	-795.	0.009956	302.3	0.019543	593.3
36	0.104807	-0.03193	-112.	0.030498	107.5	0.029799	105.0
37	0.091089	-0.01810	-123.	0.019281	131.9	0.013426	91.92
38	0.080078	-0.02301	-166.	0.027788	201.3	0.009027	65.41
39	0.070049	-0.01212	-791.	-0.00290	-189.	0.016561	1081.
40	0.051831	-0.02197	-191.	0.018324	159.9	0.015111	131.8
41	0.128710	-0.00197	-6.58	0.017261	57.71	0.014620	48.87
42	0.161327	-0.00214	-6.72	-0.01363	-42.8	0.047616	149.5
44	0.086179	-0.00379	27.60	-0.00080	5.895	-0.00913	66.49
45	0.012525	-0.00144	-7.67	0.001470	7.817	0.018780	99.85
46	0.039779	-0.00553	44.96	-0.00040	3.269	-0.00637	51.76

cont

S N	Growth	in %	Composition of V.Added coal	in %	oil	in %	petroleum	in %
1	0.010190	50.33	-0.00103	-5.10	0.004211	20.80	0.026009	128.
2	0.006024	22.14	-0.00055	-2.02	0.001228	4.516	0.005887	21.6
3	0.015192	-49.6	-0.00243	7.963	0.014890	-48.6	0.033657	-110
4	0.002479	14.35	-0.00019	-1.11	0.001323	7.663	0.012137	70.2
5	0.003373	38.05	-0.00065	-7.40	0.000168	1.902	0.006806	76.7
6	0.002619	81.64	-0.00005	-1.86	-0.00022	-7.06	0.003215	100.
7	0.004706	-772.	-0.00038	62.49	-0.00025	41.10	-0.00207	340.
10	0.051018	-47.5	-0.02118	19.74	-0.00103	0.962	-0.06757	62.9
11	0.035622	-44.4	-0.02451	30.57	-0.00033	0.421	-0.07482	93.3
12	0.025500	-51.5	-0.00959	19.40	-0.00089	1.800	0.004937	-9.9
13	0.011430	46.99	-0.00966	-39.7	0.000430	1.769	0.038067	156.
14	0.016916	-87.2	-0.00781	40.32	-0.00145	7.499	0.007253	-37.
15	0.022495	2651.	-0.00333	-393.	-0.00612	-722.	-0.01549	1725
16	0.010000	11.66	-0.00447	-5.22	-0.00978	-11.4	0.037371	43.6
17	0.024305	-126.	-0.02145	111.6	-0.00920	47.91	0.019385	-100
18	0.016563	-103.	-0.00680	42.29	-0.00462	28.75	-0.00962	59.8
19	0.027268	-68.0	-0.00337	8.410	-0.00079	1.992	-0.06025	150.
20	0.030089	103.2	-0.03492	-119.	-0.00124	-4.26	-0.00097	-3.3
21	0.011966	-224.	-0.00480	90.23	-0.00118	22.28	0.005810	-109
22	0.023057	-311.	-0.01622	219.1	0.001168	-15.7	0.008149	-110
23	0.018197	20.42	-0.00649	-7.29	-0.00982	-11.0	0.075954	85.2
25	0.094623	-362.	-0.14822	568.2	-0.00039	1.507	-0.02727	104.
26	0.036471	16.09	-0.00315	-1.39	0.041011	18.10	0.176612	77.9
27	0.020198	-164.	-0.01473	120.2	-0.00140	11.47	-0.00076	6.24
28	0.024638	24.71	-0.01506	-15.1	-0.02953	-29.6	0.105496	105.
29	0.025345	155.6	-0.02159	-132.	-0.00153	-9.43	-0.00851	-52.
30	0.062136	-381.	-0.05315	326.0	-0.00037	2.280	-0.03507	215.
31	0.040868	-106.	-0.06245	163.2	-0.03857	100.8	-0.00852	22.2
32	0.040103	-1397	-0.04970	1732.	-0.00165	57.50	-0.05241	1826
33	0.027025	25.97	-0.01976	-18.9	-0.00503	-4.83	-0.00467	-4.4
34	0.018407	127.4	-0.01064	-73.7	-0.00391	-27.0	-0.01719	-118
35	0.019173	582.1	-0.01132	-343.	-0.00917	-278.	-0.00685	-208
36	0.026621	93.86	-0.01963	-69.2	-0.00165	-5.84	-0.00374	-13.
37	0.023136	158.3	-0.01176	-80.5	-0.00193	-13.2	-0.00722	-49.
38	0.020340	147.3	-0.00876	-63.5	-0.01839	-133.	-0.00448	-32.
39	0.017792	1161.	-0.00946	-617.	-0.00328	-214.	-0.00364	-237
40	0.013165	114.8	-0.00880	-76.8	-0.00279	-24.3	0.003584	31.2
41	0.032692	109.2	-0.01914	-64.0	-0.00077	-2.57	-0.01503	-50.
42	0.040977	128.6	-0.00277	-8.72	-0.00079	-2.50	0.015248	47.8
44	0.021889	-159.	-0.01807	131.5	-0.00523	38.09	-0.00207	15.1
45	0.003181	16.91	-0.00081	-4.34	-0.00018	-0.99	0.011396	60.5
46	0.010104	-82.0	-0.00211	17.16	-0.00092	7.539	0.003206	-26.

cont

S N	elec'ty	in %	T.Energy	in %	Total Eff	in %	Energy Cost 84.
1	0.001036	5.120	0.030223	149.2	0.020244	100	0.060363
2	0.006453	23.72	0.013018	47.86	0.027199	100	0.050918
3	-0.01028	33.62	0.035829	-117.	-0.03058	100	0.029232
4	0.002049	11.86	0.015318	88.70	0.017269	100	0.027031
5	0.000140	1.589	0.006459	72.87	0.008863	100	0.022145
6	0.001485	46.27	0.004413	137.5	0.003208	100	0.013523
7	-0.00172	283.8	-0.00443	728.1	-0.00060	100	0.017921
10	-0.01766	16.45	-0.10745	100.1	-0.10730	100	0.093557
11	-0.00515	6.425	-0.10482	130.7	-0.08015	100	0.060085
12	-0.03630	73.39	-0.04186	84.62	-0.04946	100	0.050928
13	0.008007	32.92	0.036838	151.4	0.024323	100	0.069327
14	-0.00178	9.209	-0.00380	19.62	-0.01938	100	0.047210
15	0.022977	2708.	-0.00197	-233.	0.000848	100	0.089412
16	0.066416	77.48	0.089523	104.4	0.085711	100	0.125083
17	0.031377	-163.	0.020101	-104.	-0.01921	100	0.076475
18	0.010112	-62.8	-0.01094	68.04	-0.01607	100	0.049131
19	-0.01366	34.09	-0.07809	194.7	-0.04009	100	0.067263
20	0.028550	97.92	-0.00858	-29.4	0.029154	100	0.147617
21	0.000256	-4.81	0.000078	-1.47	-0.00532	100	0.041789
22	0.012718	-171.	0.005814	-78.5	-0.00740	100	0.083375
23	0.023232	26.06	0.082858	92.97	0.089116	100	0.160762
25	0.014059	-53.9	-0.16183	620.4	-0.02608	100	0.346451
26	-0.02944	-12.9	0.185026	81.67	0.226539	100	0.370128
27	0.011473	-93.6	-0.00543	44.32	-0.01225	100	0.067264
28	0.054563	54.73	0.115457	115.8	0.099679	100	0.196681
29	0.017974	110.3	-0.01367	-83.9	0.016288	100	0.116074
30	0.004348	-26.6	-0.08424	516.8	-0.01629	100	0.228331
31	0.018052	-47.1	-0.09149	239.1	-0.03825	100	0.122647
32	0.034810	-1213	-0.06895	2403.	-0.00286	100	0.155018
33	0.100217	96.31	0.070749	67.99	0.104050	100	0.210448
34	0.029028	200.9	-0.00272	-18.8	0.014447	100	0.086917
35	0.027728	841.8	0.000369	11.21	0.003293	100	0.078781
36	0.028216	99.48	0.003178	11.20	0.028361	100	0.133168
37	0.011218	76.79	-0.00970	-66.4	0.014607	100	0.105696
38	0.020334	147.3	-0.01131	-81.9	0.013800	100	0.093879
39	0.015158	989.7	-0.00123	-80.3	0.001531	100	0.071580
40	0.009956	86.88	0.001946	16.98	0.011459	100	0.063290
41	0.016884	56.44	-0.01807	-60.4	0.029911	100	0.158621
42	-0.00503	-15.8	0.006639	20.85	0.031840	100	0.193167
44	-0.00563	41.02	-0.03102	225.8	-0.01373	100	0.072442
45	0.005207	27.68	0.015598	82.94	0.018807	100	0.031332
46	-0.01664	135.1	-0.01647	133.8	-0.01231	100	0.027466

Note: For name of the Sectors see Table 3.1.

products(23), fertiliser(26), synthetic fiber & resin(28), other chemicals(29), non-ferrous metals(33), machineries and equipments(34, 35, 36, 37, 38, 39), other manufacturing(40), transport services(41,42), communication(45), while for the rest it is negative. As is evident from the Table 6.7 the contribution meted out of this growth effect were high in some sectors. For instance, for sector cotton textiles(15) it was 2651%, for electronics and communication equipments(39) it was 1161% and for electrical machineries(35) it was 582.1%. On the other hand the effect had a negative impact in sectors like iron & steel(32) where it was -1397%, in fishing(7) it was -772% , in cement(30) it was -381%. This shows that had the factor prices increased by the growth factor, energy cost in these sectors would have varied by more than the total change. But actually the factor prices of different sectors increased differently and not by the growth factor. The effect of actual change in factor energy cost is shown by the composition of value added of energy. This effect shows the difference between the actual changes in factor prices and the growth factor for different sectors. The sum of the above two effects namely the growth effect and the composition of value added effect gives the impact due to the change in total value added.

As is seen from the Table 6.7, for some sectors the major momentum to energy cost changes came from effects of changes in the composition of value added. This composition shows ceteris peribus how much the cost of different sectors would have changed due to changes in composition of value added. This effect was negative for sectors such as ' `, fishing(7), iron ore(10), other food products(14), woolen textiles(17), other textiles(18), wood and wood products(19), leather & leather products(21), rubber & rubber products(22), coal tar products(25), pesticides(27), cement(30), other non-metalic minerals(31), iron & steel(32), construction(44), other services(46) while for some sectors the contribution of the value added effect in the total change was very high. For instance, the contribution of this effect in iron & steel(32),

fishing(7), coal tar products(25), cement(30), were 2403%, 728.1%, 620.4%, and 516.8% respectively. Whe eas for some other important sectors this contribution was as follows; 239% in non-metalic mineral products(31), 225% in construction(44), 194% in wood and wood products(19), 151% in khandsari & boora(13), 149% in cereals(1), 137% in forest & logging(6), 130% in other minerals(11), 115% in synthetic fiber & resin(28), 104% in art silk & synthetic textiles(16), and 101.1% in iron ore(10). This shows that the changes in value added would have changed the energy cost by more than the total change. On the other hand for sectors like cotton textiles(15), tea & coffee(3), woolen textiles(17), the value added effect helped in changing the energy cost by more than the total change. The respective shares of this effect were -233% in cotton textiles(15), -117% in tea & coffee(3), -104% in woolen textiles(17).

Similar to the growth and composition of value added effect, the technology effect was also very much important in some sectors. For instance the share of the technology effect was by 302% in electrical machineries(35), 220% in rubber products(22), 205% in non-electrical machineries(34), 201% in other transport equipments(38), 166% in leather & leather products(21), 159% in fishing(7), 131% in motor vehicles(37), 129% in woolen textiles(17), 112% in tea & coffee(3), and 107% in rail equipments(36). On the other hand the effect was negative in sectors like cotton textiles(15), iron & steel (32), electronics and communication equipments(39), coal tar products(25), the contributions being -1771%, 1493%, -189%, and -188% respectively.

The effect of interaction of value added and the changes in I-O coefficients contributed -119.78% in the total cost of the Indian economy. Analysing sectoral details we see from the Table 6.7, the contribution of interaction effect was significant in sectors like iron & steel(32), rubber & rubber products(22), woolen textiles(17), leather & leather products(21), tea & coffee(3), pesticides(27), where the contribution were positively high. On the other hand in sectors like cotton textiles(15),

machineries and equipments(34, 35, 36, 37, 38, 39), other manufacturings(40) the contribution were negatively high.

The analysis of energy cost changes during the second sub-period 1984-85 to 1989-90 is shown in the Table 6.8. During this period the overall cost fall in the Indian economy was 5.33% as compared to a rise in cost 10.88% in 1979-80 to 1984-85. The contribution of the sub-components in the total changes of the Indian economy during the second period is as follows:-

During this period the major impulses for the changes in the total energy cost was from the value added effect whose contribution was around 90.09% of the total, out of which -829.59% was due to the growth of value added while the 919.68% was due to the composition of value added. The contribution from the technological effect and the interaction effect were -13.92% and 23.83% respectively of the total change.

As far as the value added effect is concerned, the sectors influenced much by this effects were cereals(1), woolen textiles(17), paper & paper products(20), rubber products(22), plastic & plastic products(23), pesticides(27), other chemicals(29), other non-metalic minerals(31), non-electrical & electrical machineries(34, 35), other manufacturings(40), other transport(42), and communication(45). On the other hand sectors like cereals(1), fiber crops(2), sugar(12), cotton textiles(15), woolen textiles(17), other textiles(18), pesticides(27), other chemicals(29), non-electrical & electrical(34,35), other manufacturings(40), other services(46) were the most affected due to the technological effects. And finally the interaction effect which was 23.83% of the total change had positively affected in sectors like non-electrical machineries(34), other chemicals(29), and forest & logging(6) whereas it had a negative impact in sectors like woolen textiles(17), construction(44), cereals(1), and sugar(12).

Table 6.8 Components of SDA of Energy cost changes during 1984-85 to 1989-90.

S N.	Energy Comp 84-85	Int Effect	in %	Tec Effect	in %	V.Added Effect	in %
1	0.060363	-0.00414	-65.6	0.017848	282.7	-0.00739	-117.
2	0.050918	-0.00808	-26.6	0.033365	109.7	0.005113	16.82
3	0.029232	0.001262	-6.84	-0.01054	57.12	-0.00917	49.71
4	0.027031	-0.00173	-13.5	0.009617	75.14	0.004915	38.40
5	0.022145	-0.00091	-27.7	0.002980	90.79	0.001212	36.93
6	0.013523	-0.00085	72 90	-0.00054	45.97	0.000222	-18.8
7	0.017921	0.000195	-5.72	-0.00147	43.20	-0.00213	62.51
10	0.093557	-0.00053	-0.91	0.003419	5.846	0.055601	95.07
11	0.060085	-0.00084	-4.07	0.004110	19.92	0.017354	84.14
12	0.050928	-0.00352	-57.3	0.012860	209.1	-0.00318	-51.7
13	0.069327	-0.00027	-0.69	0.004531	11.54	0.034999	89.14
14	0.047210	0.000634	5.218	0.006615	54.36	0.004917	40.41
15	0.089412	-0.00458	-17.5	0.030770	117.6	-0.00002	-0.09
16	0.125083	0.008760	66.13	-0.00357	-27.0	0.008063	60.87
17	0.076475	-0.00175	-124.	0.007044	498.7	-0.00387	-274.
18	0.049131	-0.00228	-21.8	0.011353	108.9	0.001348	12.93
19	0.067263	0.004363	-10.7	-0.02033	50.16	-0.02455	60.59
20	0.147617	-0.00878	46.44	0.017145	-90.6	-0.02727	144.2
21	0.041789	-0.00235	-12.0	0.017824	91.20	0.004075	20.85
22	0.083375	0.004586	-28.5	0.003451	-21.4	-0.02412	149.9
23	0.160762	-0.00278	4.648	0.009529	-15.9	-0.06666	111.2
25	0.346451	-0.00174	-4.60	0.012786	33.82	0.026754	70.78
26	0.370128	0.007928	-6.67	-0.02330	19.61	-0.10346	87.05
27	0.067264	0.000530	-26.8	-0.00689	349.0	0.004390	-222.
28	0.196681	-0.00151	3.104	0.007668	-15.7	-0.05492	112.6
29	0.116074	-0.00386	216.2	-0.01250	699.4	0.014578	-815.
30	0.228331	0.000937	-1.13	-0.01636	19.76	-0.06737	81.36
31	0.122647	-0.00515	-9.66	-0.00361	-6.77	0.062092	116.4
32	0.155018	0.000501	1.759	0.002263	7.945	0.025716	90.29
33	0.210448	0.003418	6.068	0.029961	53.17	0.022960	40.75
34	0.086917	-0.00266	285.9	-0.00784	843.2	0.009574	-1029
35	0.078781	-0.00301	56.78	-0.00919	173.2	0.006899	-130.
36	0.133168	-0.00764	9.590	-0.05959	74.75	-0.01248	15.65
37	0.105696	0.000945	-11.3	-0.00502	60.50	-0.00422	50.86
38	0.093879	-0.00157	4.475	-0.02048	58.14	-0.01316	37.37
39	0.071580	-0.00067	1.782	-0.02684	71.10	-0.01023	27.11
40	0.063290	-0.00183	-29.1	-0.00748	-118.	0.015631	247.8
41	0.158621	-0.00235	6.983	-0.00017	0.513	-0.03115	92.50
42	0.193167	-0.00448	9.141	0.018863	-38.4	-0.06347	129.2
44	0.072442	-0.00678	-75.3	0.007394	82.19	0.008385	93.20
45	0.031332	-0.00112	8.754	0.002995	-23.3	-0.01468	114.6
46	0.027466	-0.00094	16.56	-0.00657	114.9	0.001803	-31.5

cont

S N	Growth	in %	Composition of V.Added coal	in %	oil	in %	petroleum	in %
1	0.026680	422.6	-0.00013	-2.20	-0.00227	-36.0	-0.03272	-518
2	0.022506	74.05	-0.00074	-2.46	-0.00196	-6.47	-0.01186	-39.
3	0.012920	-70.0	-0.00064	3.499	-0.00920	49.89	-0.00858	46.5
4	0.011947	93.34	-0.00005	-0.43	-0.00133	-10.4	-0.00601	-47.
5	0.009788	298.1	0.000324	9.870	-0.00071	-21.8	-0.00644	-196
6	0.005977	-507.	-0.00111	94.68	-0.00001	1.056	-0.00089	76.1
7	0.007921	-232.	0.000198	-5.80	-0.00000	0.273	-0.00843	246.
10	0.041352	70.70	0.000420	0.719	-0.00000	-0.00	-0.02535	-43.
11	0.026557	128.7	0.000317	1.537	-0.00000	-0.02	-0.00112	-5.4
12	0.022510	366.1	0.001747	28.41	-0.00085	-13.9	-0.01696	-275
13	0.030642	78.05	0.006539	16.65	-0.00069	-1.77	0.002566	6.53
14	0.020867	171.4	0.004279	35.17	-0.00117	-9.68	-0.00967	-79.
15	0.039520	151.0	0.005535	21.16	-0.00065	-2.49	0.000697	2.66
16	0.055286	417.3	0.002589	19.54	-0.00025	-1.92	-0.01409	-106
17	0.033802	2393.	0.006955	492.4	-0.00013	-9.80	0.001857	131.
18	0.021716	208.3	0.003473	33.33	-0.00027	-2.63	-0.00026	-2.5
19	0.029730	-73.3	0.000523	-1.29	-0.00014	0.351	-0.00658	16.2
20	0.065246	-345.	0.014761	-78.0	-0.00016	0.848	-0.01572	83.1
21	0.018470	94.51	0.002409	12.32	-0.00029	-1.51	-0.00491	-25.
22	0.036852	-229.	0.001336	-8.30	-0.00026	1.677	-0.01750	108.
23	0.071056	-118.	0.002604	-4.34	-0.00014	0.236	-0.10330	172.
25	0.153131	405.1	-0.10324	-273.	-0.00008	-0.21	-0.00651	-17.
26	0.163596	-137.	-0.01606	13.52	-0.04549	38.28	-0.17298	145.
27	0.029730	-1504	0.000599	-30.3	-0.00024	12.25	0.002447	-123
28	0.086933	-178.	0.007884	-16.1	-0.00024	0.497	-0.08781	180.
29	0.051304	-2870	0.003006	-168.	-0.00019	11.11	0.018297	-480
30	0.100922	-121.	-0.05062	61.13	-0.00019	0.236	-0.02631	31.7
31	0.054209	101.6	0.026508	49.70	0.000508	0.954	0.028080	52.6
32	0.068518	240.5	0.014791	51.93	0.000217	0.762	0.023474	82.4
33	0.093018	165.0	0.000791	1.405	0.000473	0.840	0.030006	53.2
34	0.038417	-4129	0.005021	-539.	0.000042	-4.58	0.013565	-125
35	0.034821	-656.	0.003296	-62.1	0.000033	-0.62	0.009991	-188
36	0.058860	-73.8	0.005830	-7.31	0.000106	-0.13	-0.00831	10.4
37	0.046717	-562.	0.002755	-33.1	-0.00003	0.367	-0.01450	174.
38	0.041494	-117.	0.004481	-12.7	-0.00006	0.197	-0.01598	45.3
39	0.031638	-83.7	0.001777	-4.70	0.000046	-0.12	-0.00879	23.2
40	0.027974	443.5	0.005314	84.25	-0.00001	-0.24	0.003667	58.1
41	0.070110	-208.	-0.03567	105.9	-0.00001	0.054	-0.03948	117.
42	0.085379	-173.	0.000646	-1.31	-0.00002	0.052	-0.15221	309.
44	0.032019	355.9	-0.00055	-6.16	-0.00006	-0.70	-0.01224	-136
45	0.013848	-108.	-0.00044	3.465	-0.00001	0.079	-0.02064	161.
46	0.012140	-212.	0.000464	-8.10	-0.00045	7.919	-0.00630	110.

cont

S N	elec'ty	in %	T.Energy	in %	Total Eff	in %	Energy Cost 89
1	0.001066	16.88	-0.03407	-539.	0.006312	100	0.066675
2	-0.00281	-9.24	-0.01739	-57.2	0.030389	100	0.081308
3	-0.00365	19.82	-0.02209	119.7	-0.01845	100	0.010776
4	0.000377	2.953	-0.00703	-54.9	0.012799	100	0.039830
5	-0.00173	-52.8	-0.00857	-261.	0.003283	100	0.025428
6	-0.00373	317.0	-0.00575	488.9	-0.00117	100	0.012346
7	-0.00181	53.11	-0.01005	294.5	-0.00341	100	0.014507
10	0.039185	67.00	0.014248	24.36	0.058483	100	0.152040
11	-0.00838	-40.6	-0.00920	-44.6	0.020623	100	0.080709
12	-0.00962	-156.	-0.02569	-417.	0.006147	100	0.057076
13	-0.00405	-10.3	0.004357	11.09	0.039259	100	0.108586
14	-0.00938	-77.0	-0.01594	-131.	0.012167	100	0.059378
15	-0.04512	-172.	-0.03954	-151.	0.026157	100	0.115569
16	-0.03546	-267.	-0.04722	-356.	0.013247	100	0.138330
17	-0.04635	-3281	-0.03767	-2667	0.001412	100	0.077887
18	-0.02330	-223.	-0.02036	-195.	0.010420	100	0.059552
19	-0.04808	118.6	-0.05428	133.9	-0.04052	100	0.026736
20	-0.09139	483.3	-0.09251	489.2	-0.01890	100	0.128708
21	-0.01159	-59.3	-0.01439	-73.6	0.019542	100	0.061331
22	-0.04454	276.8	-0.06098	378.9	-0.01609	100	0.067284
23	-0.03688	61.55	-0.13772	229.8	-0.05992	100	0.100840
25	-0.01654	-43.7	-0.12637	-334.	0.037799	100	0.384250
26	-0.03250	27.35	-0.26706	224.7	-0.11884	100	0.251280
27	-0.02814	1424.	-0.02534	1282.	-0.00197	100	0.065288
28	-0.06168	126.4	-0.14185	290.8	-0.04876	100	0.147912
29	-0.05783	3235.	-0.03672	2054.	-0.00178	100	0.114287
30	-0.09115	110.0	-0.16829	203.2	-0.08280	100	0.145523
31	-0.04721	-88.5	0.007882	14.78	0.053326	100	0.175973
32	-0.08128	-285.	-0.04280	-150.	0.028480	100	0.183499
33	-0.10132	-179.	-0.07005	-124.	0.056340	100	0.266789
34	-0.04747	5103.	-0.02884	3100.	-0.00093	100	0.085987
35	-0.04124	777.3	-0.02792	526.2	-0.00530	100	0.073475
36	-0.06896	86.50	-0.07134	89.48	-0.07972	100	0.053443
37	-0.03916	471.1	-0.05094	612.9	-0.00831	100	0.097384
38	-0.04309	122.3	-0.05466	155.1	-0.03522	100	0.058650
39	-0.03490	92.45	-0.04187	110.9	-0.03775	100	0.033820
40	-0.02130	-337.	-0.01234	-195.	0.006307	100	0.069597
41	-0.02608	77.44	-0.10126	300.6	-0.03368	100	0.124940
42	0.002733	-5.56	-0.14885	303.1	-0.04910	100	0.144063
44	-0.01077	-119.	-0.02363	-262.	0.008996	100	0.081439
45	-0.00743	58.01	-0.02853	222.7	-0.01281	100	0.018520
46	-0.00404	70.68	-0.01033	180.6	-0.00572	100	0.021743

Note: For name of the Sectors see Table 3.1.

The results of similar analysis for the third sub-period i.e 1989-90 to 1991-92 is shown in Table 6.9. Over this period the energy cost of the Indian economy as a whole was declined by 6.64% while it had declined by 5.33% during the previous period i.e 1984-85 to 1989-90. In this period the energy cost had increased significantly for the sectors like fiber crops(2), iron ore(10), khandaṣari & boora(13), other non-metalic minerals(31), iron & steel(32), non-ferrous metals(33) in 1991-92 as compared to 1989-90. While the sectors which experienced a significant decline in the energy cost were fertiliser(26), synthetic fiber & resin(28), rail equipments(36), other transport equipments(38), rail transport(41), and other transport(42). From the Table 6.9 we observed that the contribution of value added effects in the total energy cost change of the Indian economy during 1989-90 to 1991-92 was 63.87%, which was lower than the previous periods. On the other hand the share of the technological effect was 30.41% which was higher than the shares of the previous two sub periods where the contributions were 19.1% and -13.92% respectively. And finally as far as the interaction effect of value added and technology is concerned, it had declined from 23.83% during 1984-85 to 1989-90 to 5.70% during this sub-period. If we further subdivide the value added effect into growth and composition of value added effect, it is evident from the table that the impact of the growth effect had increased significantly from -829.59% during 1984-85 to 1989-90 to only -114.3% in this sub-period whereas the composition of value added had increased to 87.26% from 31.26% in the previous period.

The sectoral details of energy cost change from the Table 6.9 shows that the contribution of growth effect was significant in the following sectors; it was 229.2% of the total change in construction(44), 120.5% in forest & logging(6), 111.2% in non-electrical machineries(34). Again there were sectors where the contribution was both significant and negative. For instance, in tea & coffee(3) it was -272%, in cotton textiles(15) it was -183%, in synthetic fiber & resin(28) it was -111%. This shows that in the above mentioned sectors the impact of growth effect

Table 6.9 Components of SDA of Energy cost changes during 1989-90 to 1991-92.

S N.	Energy Comp 89-90	Int Effect	in %	Tec Effect	in %	V.Added Effect	in %
1	0.066675	-0.00136	-7.82	0.004121	23.68	0.014640	84.14
2	0.081308	0.000882	-4.83	-0.00803	44.07	-0.01107	60.76
3	0.010776	0.000409	-136.	0.000343	-114.	-0.00105	351.2
4	0.039830	0.000335	-2.94	-0.00284	25.03	-0.00885	77.91
5	0.025428	0.000655	-17.3	-0.00256	67.81	-0.00187	49.54
6	0.012346	-0.00040	-51.8	-0.00069	-89.0	0.001874	240.9
7	0.014507	0.000188	0.954	0.003215	16.31	0.016312	82.73
10	0.152040	-0.00019	0.586	-0.00138	4.132	-0.03191	95.28
11	0.080709	-0.00039	1.556	-0.00228	8.914	-0.02294	89.52
12	0.057076	-0.00138	13.66	-0.00762	75.24	-0.00112	11.09
13	0.108586	0.000207	-0.77	-0.00919	34.33	-0.01779	66.43
14	0.059378	0.000832	6.545	0.004136	32.51	0.007753	60.94
15	0.115569	0.001340	-28.0	-0.00948	198.6	0.003370	-70.5
16	0.138330	0.004772	-16.1	0.006137	-20.7	-0.04054	136.8
17	0.077887	-0.00083	7.327	-0.00124	10.93	-0.00927	81.74
18	0.059552	-0.00064	-7.27	0.009557	108.1	-0.00007	-0.87
19	0.026736	-0.00124	35.42	-0.00307	87.38	0.000802	-22.8
20	0.128708	-0.00093	5.580	-0.01553	92.32	-0.00035	2.091
21	0.061331	-0.00165	29.46	-0.00641	114.5	0.002465	-43.9
22	0.067284	0.000115	-0.55	-0.00977	46.74	-0.01124	53.80
23	0.100840	0.001945	5.405	0.033317	92.55	0.000734	2.040
25	0.384250	-0.00043	0.520	-0.02407	28.73	-0.05925	70.74
26	0.251280	-0.00009	0.165	-0.00135	2.382	-0.05549	97.45
27	0.065288	-0.00096	12.47	-0.00206	26.75	-0.00469	60.77
28	0.147912	-0.00052	5.263	-0.02177	216.6	0.012254	-121.
29	0.114287	-0.00092	5.061	-0.00333	18.18	-0.01406	76.75
30	0.145523	-0.00130	3.751	0.006145	-17.6	-0.03963	113.9
31	0.175973	-0.00245	5.981	-0.00712	17.34	-0.03148	76.67
32	0.183499	0.000714	4.795	-0.00641	-43.0	0.020605	138.2
33	0.266789	-0.00023	0.821	-0.04363	150.4	0.014878	-51.3
34	0.085987	0.000178	3.044	0.001218	20.74	0.004478	76.21
35	0.073475	0.000246	2.865	0.002353	27.36	0.005998	69.76
36	0.053443	0.000076	-0.20	-0.01265	33.14	-0.02561	67.05
37	0.097384	-0.00131	9.823	-0.01363	101.8	0.001562	-11.6
38	0.058650	-0.00080	-1.75	0.033288	72.46	0.013450	29.28
39	0.033820	0.000690	7.415	0.007969	85.60	0.000649	6.981
40	0.069597	-0.00040	5.696	-0.00276	38.43	-0.00401	55.87
41	0.124940	-0.00710	-41.6	0.012353	72.43	0.011801	69.20
42	0.144063	-0.00145	-2.01	0.001315	1.821	0.072348	100.1
44	0.081439	-0.00225	-83.3	0.006640	245.9	-0.00168	-62.5
45	0.018520	0.000349	2.044	0.004623	27.00	0.012145	70.94
46	0.021743	-0.00010	-4.73	-0.00032	-15.4	0.002544	120.1

cont

S N	Growth	in %	Composition of V.Added coal	in %	oil	in %	petroleum	in %
1	0.005067	29.12	-0.00120	-6.89	0.000009	0.053	0.003859	22.1
2	0.006179	-33.8	-0.00168	9.254	0.000012	-0.06	-0.01039	56.9
3	0.000819	-272.	-0.00040	133.5	0.000003	-1.26	-0.00105	350.
4	0.003027	-26.6	-0.00088	7.820	0.000004	-0.03	-0.00780	68.6
5	0.001932	-51.1	-0.00058	15.37	0.000010	-0.27	-0.00262	69.5
6	0.000938	120.5	-0.00008	-10.8	0.000001	0.255	0.000316	40.6
7	0.001102	5.591	-0.00006	-0.32	0.000001	0.007	0.015240	77.2
10	0.011555	-34.4	-0.00065	1.964	0.000020	-0.06	-0.02406	71.8
11	0.006133	-23.9	-0.00046	1.829	0.000014	-0.05	-0.01580	61.6
12	0.004337	-42.8	-0.00216	21.31	0.000029	-0.28	-0.00279	27.6
13	0.008252	-30.8	-0.00434	16.22	0.000012	-0.04	-0.01582	59.0
14	0.004512	35.47	-0.00115	-9.09	0.000226	1.777	0.001614	12.6
15	0.008783	-183.	-0.00383	80.27	0.000032	-0.67	-0.00250	52.4
16	0.010513	-35.4	-0.00385	13.02	0.000036	-0.12	-0.00688	23.2
17	0.005919	-52.1	-0.00550	48.53	0.000038	-0.33	-0.00319	28.1
18	0.004525	51.21	-0.00193	-21.9	0.000020	0.233	-0.00086	-9.7
19	0.002031	-57.7	-0.00079	22.57	0.000008	-0.23	0.000135	-3.8
20	0.009781	-58.1	-0.00880	52.32	0.000070	-0.41	-0.00005	0.34
21	0.004661	-83.1	-0.00191	34.08	0.000046	-0.82	-0.00012	2.25
22	0.005113	-24.4	-0.00259	12.41	0.000066	-0.31	-0.00760	36.3
23	0.007663	21.28	-0.00133	-3.70	0.000363	1.010	0.000213	0.59
25	0.029203	-34.8	-0.09402	112.2	0.003025	-3.61	0.003019	-3.6
26	0.019097	-33.5	-0.01047	18.38	0.000002	-0.00	-0.04415	77.5
27	0.004961	-64.2	-0.00131	17.00	0.000087	-1.13	-0.00371	48.0
28	0.011241	-111.	-0.00404	40.25	0.000146	-1.45	0.003057	-30.
29	0.008685	-47.3	-0.00319	17.42	0.000324	-1.77	-0.01018	55.5
30	0.011059	-31.7	-0.02948	84.74	0.000012	-0.03	-0.00424	12.2
31	0.013373	-32.5	-0.02300	56.02	0.000125	-0.30	-0.01685	41.0
32	0.013945	93.54	-0.00212	-14.2	0.000391	2.624	0.003390	22.7
33	0.020276	-69.9	-0.00272	9.407	0.000401	-1.38	-0.00173	5.98
34	0.006535	111.2	-0.00165	-28.1	0.000125	2.137	-0.00013	-2.3
35	0.005584	64.94	-0.00114	-13.3	0.000122	1.423	0.000990	11.5
36	0.004061	-10.6	-0.00268	7.030	-0.00003	0.092	-0.01396	36.5
37	0.007401	-55.2	-0.00125	9.408	0.000119	-0.89	-0.00255	19.1
38	0.004457	9.704	-0.00061	-1.32	0.000068	0.150	0.005334	11.6
39	0.002570	27.61	-0.00059	-6.42	0.000040	0.429	-0.00023	-2.5
40	0.005289	-73.6	-0.00305	42.55	0.000110	-1.53	-0.00207	28.8
41	0.009495	55.68	-0.00388	-22.7	0.000035	0.207	0.009770	57.2
42	0.010948	15.16	-0.00044	-0.60	0.000012	0.017	0.033954	47.0
44	0.006189	229.2	-0.00547	-202.	0.000132	4.922	-0.00034	-12.
45	0.001407	8.222	-0.00042	-2.48	0.000007	0.045	0.003941	23.0
46	0.001652	78.07	-0.00101	-48.0	0.000011	0.552	0.000826	39.0

cont

S N	elec'ty	in %	T.Energy	in %	Total Eff	in %	Energy Cost 91
1	0.006904	39.68	0.009572	55.01	0.017398	100	0.084074
2	-0.00519	28.46	-0.01725	94.65	-0.01823	100	0.063073
3	-0.00042	141.5	-0.00187	624.1	-0.00030	100	0.010476
4	-0.00319	28.09	-0.01188	104.5	-0.01136	100	0.028463
5	-0.00060	16.03	-0.00380	100.7	-0.00377	100	0.021651
6	0.000702	90.26	0.000936	120.3	0.000778	100	0.013124
7	0.000031	0.160	0.015210	77.14	0.019717	100	0.034224
10	-0.01876	56.03	-0.04347	129.7	-0.03349	100	0.118543
11	-0.01282	50.03	-0.02907	113.4	-0.02562	100	0.055083
12	-0.00053	5.248	-0.00546	53.89	-0.01013	100	0.046941
13	-0.00589	22.00	-0.02604	97.25	-0.02677	100	0.081807
14	0.002556	20.09	0.003240	25.46	0.012722	100	0.072100
15	0.000893	-18.7	-0.00541	113.3	-0.00477	100	0.110794
16	-0.04034	136.1	-0.05105	172.2	-0.02963	100	0.108696
17	-0.00653	57.56	-0.01519	133.9	-0.01134	100	0.066542
18	-0.00182	-20.6	-0.00460	-52.0	0.008836	100	0.068389
19	-0.00057	16.49	-0.00122	34.98	-0.00351	100	0.023220
20	-0.00134	7.981	-0.01013	60.23	-0.01682	100	0.111883
21	-0.00020	3.662	-0.00219	39.18	-0.00560	100	0.055727
22	-0.00622	29.78	-0.01636	78.26	-0.02090	100	0.046379
23	-0.00617	-17.1	-0.00692	-19.2	0.035997	100	0.136838
25	-0.00048	0.574	-0.08846	105.6	-0.08376	100	0.300487
26	-0.01996	35.06	-0.07459	130.9	-0.05694	100	0.194333
27	-0.00471	61.06	-0.00965	125.0	-0.00772	100	0.057566
28	0.001854	-18.4	0.001013	-10.0	-0.01005	100	0.137861
29	-0.00970	52.94	-0.02275	124.1	-0.01832	100	0.095960
30	-0.01697	48.77	-0.05069	145.7	-0.03479	100	0.110732
31	-0.00512	12.48	-0.04485	109.2	-0.04105	100	0.134913
32	0.004999	33.53	0.006659	44.67	0.014907	100	0.198406
33	-0.00133	4.613	-0.00539	18.61	-0.02899	100	0.237797
34	-0.00039	-6.66	-0.00205	-34.9	0.005876	100	0.091863
35	0.000449	5.231	0.000414	4.821	0.008598	100	0.082073
36	-0.01299	34.01	-0.02967	77.69	-0.03819	100	0.015251
37	-0.00213	15.97	-0.00583	43.60	-0.01339	100	0.083994
38	0.004199	9.141	0.008992	19.57	0.045934	100	0.104584
39	-0.00112	-12.1	-0.00192	-20.6	0.009309	100	0.043130
40	-0.00428	59.60	-0.00930	129.4	-0.00718	100	0.062412
41	-0.00361	-21.2	0.002306	13.52	0.017053	100	0.141994
42	0.027873	38.60	0.061399	85.03	0.072206	100	0.216269
44	-0.00219	-81.1	-0.00787	-291.	0.002700	100	0.084140
45	0.007212	42.13	0.010737	62.72	0.017118	100	0.035639
46	0.001070	50.56	0.000891	42.12	0.002116	100	0.023860

Note: For name of the Sectors see Table 3.1.

was more than the total change. On the other hand the effect of composition of value added effect was positive in almost all sectors except other textiles(18), plastic & plastic products(23), synthetic fiber & resin(28), non-electrical machineries(34), electronic & communication equipments(39),and construction(44). As seen from the table the effect was high in sectors like primary sectors(2, 3, 4, 5, 6), minerals(10, 11), textile products(15, 16, 17), coal tar product(25), chemical products(26, 27, 29), metalic & non-metalic mineral products(30, 31), and other manufacturings(40). The value added effect,which is the sum of the growth and composition of value added effects, was significant for sectors such as tea & coffee(3), forest & logging(6), iron & steel(32), art silk & synthetic textiles(16), other services(46), cement(30), other transport(42), and synthetic fiber & resin(28). In these sectors the contribution was more than 100% of the total change.

The effect of changes in the I-O coefficients on the energy cost changes was high and positive in sectors like cotton textiles(15), other textiles(18), leather & leather products(21), synthetic fiber & resin(28), non-ferrous metals(33), and construction(44), while the contribution of the effects of changes in the I-O coefficients was high and negative in tea and coffee(3) over the period 1989-90 to 1991-92 as seen from the Table 6.9.

Finally we see that the impact of interaction effects of the changes in value added and I-O coefficients was small in almost all the sectors of the Indian economy during 1989-90 to 1991-92. Over this period the impact of this interaction effect was negative for sectors such as; primary sectors(1, 2, 3, 4, 5, 6), khandasari & boora(13), cotton textiles(15), art silk & synthetic textiles(16), other textiles(18), rubber products(22), rail equipments(36), other transport equipments(38), transport services(41, 42), construction(44), and other services(46) while for the remaining sectors the contribution was positive.

Before we conclude this section, let us discuss about the

trends in the energy cost changes for the Indian economy for the whole period under study i.e from 1979-80 to 1991-92. The results of the cost analysis for the entire period is given in the Table 6.10. Over this entire period, 1979-80 to 1991-92, the energy cost in the Indian economy decreased by 2.01% as compared to 1979-80 which shows that the share of energy as an input is declining over the years. This reflects the increase in efficiency of energy use. As is evident from the Table 6.10, the technological changes contributed to 221.2%, changes in value added contributed -501.48% to the total change in energy cost changes. The share of interaction effect of value added and changes in I-O coefficients to the total change in energy cost was 380.2%. Again if we further divide the value added, then the growth effect and the composition of value added affected the total change by -4730% and 4229% respectively.

The sectoral details of the cost change from the Table 6.10 show that the value added effect was very significant in sectors like animal husbandry(5), forest and logging(6), khandsari & borra(13), textiles except 17(14,15,16,18), paper and paper products(20), leather & leather products(21), coal tar products(25), fertiliser(26), synthetic fiber and resin(28), non-ferrous metals(33), non-electrical & electrical machineries(34,35), other manufacturings(40), and construction(44). In these sectors it was the value added which helped the most(more than 100%) in the change of the energy costs. On the other hand there were only two sectors namely other chemicals(29), and motor vehicles(37) where the impact due to value added effects was negative and more than 100%. If we see the growth effects during this period, it was very much significant(either positive or negative) in almost all sectors except cereals(1), cash crops(2), other crops(4), woolen textiles(16), and communication(45). The impact of this effect was more than 100% for the remaining sectors, the highest being experienced by sectors like other food and beverages(14), other textiles(18), paper & paper products(20), other chemicals(29),

Table 6.10 Components of SDA of Energy cost changes during 1979-80 to 1991-92.

S N.	Energy Comp 79-80	Int Effect	in %	Tec Effect	in %	V.Added Effect	in %
1	0.040118	0.000160	0.365	0.004376	9.956	0.039418	89.67
2	0.023718	0.004687	11.91	0.015882	40.35	0.018785	47.73
3	0.059814	-0.01690	34.26	-0.04048	82.04	0.008046	-16.3
4	0.009762	0.000562	3.010	0.003832	20.49	0.014306	76.49
5	0.013281	-0.00167	-19.9	0.001651	19.73	0.008391	100.2
6	0.010314	-0.00072	-25.7	-0.00487	-173.	0.008406	299.1
7	0.018531	0.000548	3.493	0.000205	1.311	0.014939	95.19
10	0.200860	-0.01627	19.77	-0.03770	45.80	-0.02833	34.41
11	0.140244	-0.00603	7.089	-0.00506	5.943	-0.07406	86.96
12	0.100396	-0.00541	10.12	-0.02665	49.85	-0.02139	40.01
13	0.045003	-0.01282	-34.8	-0.01557	-42.3	0.065201	177.1
14	0.066599	-0.00421	-76.6	-0.00875	-159.	0.018472	335.8
15	0.088563	-0.00011	-0.51	-0.00241	-10.8	0.024757	111.3
16	0.039371	0.000499	0.720	-0.00088	-1.27	0.069713	100.5
17	0.095689	-0.01769	60.70	-0.02991	102.6	0.018461	-63.3
18	0.065210	0.000191	6.023	-0.00321	-101.	0.006205	195.2
19	0.107358	-0.00423	5.033	-0.01003	11.93	-0.06986	83.03
20	0.118462	-0.00033	5.096	0.001137	-17.2	-0.00738	112.1
21	0.047111	-0.00896	-104.	0.000223	2.598	0.017355	201.4
22	0.090777	-0.00335	7.553	-0.02554	57.54	-0.01549	34.90
23	0.071645	0.029546	45.32	0.012843	19.70	0.022803	34.97
25	0.372533	-0.00923	12.82	0.034449	-47.8	-0.09725	134.9
26	0.143588	-0.00398	-7.85	-0.01230	-24.2	0.067031	132.0
27	0.079521	-0.01299	59.18	-0.02516	114.6	0.016205	-73.8
28	0.097002	-0.01746	-42.7	-0.03531	-86.4	0.093644	229.1
29	0.099786	-0.00665	173.9	-0.00754	197.2	0.010378	-271.
30	0.244630	-0.00729	5.449	0.002727	-2.03	-0.12932	96.58
31	0.160898	-0.01076	41.42	0.004205	-16.1	-0.01942	74.75
32	0.157888	-0.00784	-19.3	0.034811	85.91	0.013555	33.45
33	0.106398	-0.01171	-8.91	0.003378	2.571	0.139740	106.3
34	0.072470	-0.02457	-126.	0.015179	78.27	0.028788	148.4
35	0.075487	-0.01707	-259.	-0.00769	-116.	0.031363	476.2
36	0.104807	-0.02524	28.18	-0.05645	63.04	-0.00785	8.771
37	0.091089	-0.01116	157.3	-0.00432	60.89	0.008389	-118.
38	0.080078	-0.01549	-63.2	0.028369	115.7	0.011631	47.46
39	0.070049	-0.01061	39.42	-0.02541	94.40	0.009108	-33.8
40	0.051831	-0.00840	-79.3	0.002645	24.99	0.016337	154.3
41	0.128710	-0.01676	-126.	0.028816	216.9	0.001228	9.248
42	0.161327	0.001089	1.982	0.003552	6.465	0.050301	91.55
44	0.086179	-0.01298	636.5	0.013819	-677.	-0.00287	141.1
45	0.012525	-0.00157	-6.82	0.008536	36.93	0.016155	69.89
46	0.039779	-0.00369	23.20	-0.00807	50.72	-0.00415	26.07

cont

S N	Growth	in %	Composition of V.Added coal	in %	oil	in %	petroleum	in %
1	0.038112	86.70	-0.00427	-9.73	0.001600	3.641	-0.00301	-6.8
2	0.022532	57.25	-0.00197	-5.01	0.000352	0.894	-0.00773	-19.
3	0.056823	-115.	-0.01169	23.71	0.003881	-7.86	-0.00813	16.4
4	0.009274	49.58	-0.00109	-5.83	0.000546	2.920	0.004904	26.2
5	0.012617	150.7	-0.00151	-18.0	-0.00061	-7.39	0.000110	1.31
6	0.009798	348.6	-0.00198	-70.5	-0.00037	-13.4	0.000981	34.9
7	0.017604	112.1	-0.00068	-4.39	-0.00045	-2.87	0.001770	11.2
10	0.190817	-231.	-0.04084	49.62	-0.00142	1.734	-0.15709	190.
11	0.133232	-156.	-0.03908	45.89	-0.00048	0.570	-0.13397	157.
12	0.095376	-178.	-0.01664	31.13	-0.00220	4.125	-0.02518	47.1
13	0.042753	116.1	-0.01198	-32.5	-0.00156	-4.26	0.035458	96.3
14	0.063269	1150.	-0.01068	-194.	-0.00703	-127.	-0.01090	-198
15	0.084135	378.4	-0.00200	-9.00	-0.01016	-45.7	-0.02974	-133
16	0.037402	53.95	-0.00757	-10.9	-0.01545	-22.2	0.020716	29.8
17	0.090904	-311.	-0.03138	107.6	-0.01458	50.04	-0.00466	16.0
18	0.061950	1949.	-0.00967	-304.	-0 00764	-240.	-0.02271	-714
19	0.101990	-121.	-0.00632	7.522	-0.00134	1.604	-0.10464	124.
20	0.112539	-1710	-0.04938	750.5	-0.00196	29.87	-0.02097	318.
21	0.044755	519.4	-0.00702	-81.5	-0.00291	-33.8	-0.00592	-68.
22	0.086238	-194.	-0.02941	66.25	-0.00235	5.302	-0.03644	82.0
23	0.068063	104.4	-0.01096	-16.8	-0.01534	-23.5	-0.00779	-11.
25	0.353906	-491.	-0.41667	578.3	0.002050	-2.84	-0.04090	56.7
26	0.136409	268.8	-0.03518	-69.3	0.018013	35.49	0.049127	96.8
27	0.075545	-344.	-0.02505	114.1	-0.00222	10.13	-0.01059	48.2
28	0.092152	225.5	-0.02020	-49.4	-0.04657	-113.	0.053479	130.
29	0.094796	-2477	-0.03798	992.8	-0.00214	55.95	-0.01061	277.
30	0.232399	-173.	-0.16739	125.0	-0.00101	0.755	-0.08720	65.1
31	0.152853	-588.	-0.09262	356.4	-0.05928	228.1	-0.00289	11.1
32	0.149993	370.1	-0.05963	-147.	-0.00212	-5.24	-0.06310	-155
33	0.101078	76.92	-0.02829	-21.5	-0.00691	-5.26	0.023365	17.7
34	0.068846	355.0	-0.01446	-74.5	-0.00586	-30.2	-0.01525	-78.
35	0.071713	1088.	-0.01696	-257.	-0.01403	-213.	-0.00465	-70.
36	0.099566	-111.	-0.03062	34.20	-0.00240	2.689	-0.03804	42.4
37	0.086535	-1219	-0.01798	253.4	-0.00324	45.68	-0.03645	513.
38	0.076074	310.4	-0.01144	-46.7	-0.02860	-116.	-0.01967	-80.
39	0.066546	-247.	-0.01443	53.62	-0.00495	18.39	-0.01964	72.9
40	0.049239	465.3	-0.01375	-129.	-0.00448	-42.3	-0.01079	-102
41	0.122274	920.4	-0.07154	-538.	-0.00118	-8.95	-0.04895	-368
42	0.153260	278.9	-0.00422	-7.68	-0.00161	-2.94	-0.11426	-207
44	0.081870	-4014	-0.03221	1579.	-0.00815	400.1	-0.02668	1308
45	0.011899	51.48	-0.00170	-7.39	-0.00030	-1.33	-0.00175	-7.6
46	0.037790	-237.	-0.00411	25.83	-0.00196	12.36	-0.00672	42.2

con.

S N	elec'ty	in %	T.Energy	in %	Total Eff	in %	Energy Cost 91.
1	0.007000	15.92	0.001305	2.971	0.043955	100	0.084074
2	0.005607	14.24	-0.00374	-9.52	0.039355	100	0.063073
3	-0.03282	66.54	-0.04877	98.86	-0.04933	100	0.010476
4	0.000671	3.590	0.005032	26.90	0.018701	100	0.028463
5	-0.00220	-26.3	-0.00422	-50.4	0.008369	100	0.021651
6	-0.00001	-0.47	-0.00139	-49.5	0.002810	100	0.013124
7	-0.00329	-20.9	-0.00266	-16.9	0.015693	100	0.034224
10	-0.01977	24.02	-0.21915	266.2	-0.08231	100	0.118543
11	-0.03374	39.62	-0.20729	243.4	-0.08516	100	0.055083
12	-0.07273	136.0	-0.11676	218.4	-0.05345	100	0.046941
13	0.000542	1.474	0.022448	60.99	0.036804	100	0.081807
14	-0.01617	-294.	-0.04479	-814.	0.005500	100	0.072100
15	-0.01746	-78.5	-0.05937	-267.	0.022230	100	0.110794
16	0.034621	49.94	0.032310	46.60	0.069325	100	0.108696
17	-0.02180	74.81	-0.07244	248.5	-0.02914	100	0.066542
18	-0.01570	-494.	-0.05574	-1753	0.003178	100	0.068389
19	-0.05953	70.75	-0.17185	204.2	-0.08413	100	0.023220
20	-0.04759	723.4	-0.11992	1822.	-0.00657	100	0.111883
21	-0.01154	-133.	-0.02740	-318.	0.008615	100	0.055727
22	-0.03352	75.50	-0.10173	229.1	-0.04439	100	0.046379
23	-0.01115	-17.1	-0.04526	-69.4	0.065192	100	0.136838
25	0.004358	-6.04	-0.45116	626.2	-0.07204	100	0.300487
26	-0.10133	-199.	-0.06937	-136.	0.050744	100	0.194333
27	-0.02147	97.79	-0.05933	270.2	-0.02195	100	0.057566
28	0.014787	36.19	0.001492	3.653	0.040859	100	0.137861
29	-0.03367	880.1	-0.08441	2206.	-0.00382	100	0.095960
30	-0.10611	79.25	-0.36172	270.1	-0.13389	100	0.110732
31	-0.01747	67.24	-0.17227	662.9	-0.02598	100	0.134913
32	-0.01157	-28.5	-0.13643	-336.	0.040518	100	0.198406
33	0.050508	38.43	0.038661	29.42	0.131398	100	0.237797
34	-0.00447	-23.0	-0.04005	-206.	0.019393	100	0.091863
35	-0.00470	-71.3	-0.04034	-612.	0.006586	100	0.082073
36	-0.03633	40.57	-0.10742	119.9	-0.08955	100	0.015251
37	-0.02046	288.4	-0.07814	1101.	-0.00709	100	0.083994
38	-0.00470	-19.2	-0.06444	-262.	0.024506	100	0.104584
39	-0.01840	68.38	-0.05743	213.3	-0.02691	100	0.043130
40	-0.00386	-36.5	-0.03290	-310.	0.010581	100	0.062412
41	0.000643	4.840	-0.12104	-911.	0.013284	100	0.141994
42	0.017151	31.21	-0.10295	-187.	0.054942	100	0.216269
44	-0.01768	866.9	-0.08474	4155.	-0.00203	100	0.084140
45	0.008031	34.74	0.004256	18.41	0.023113	100	0.035639
46	-0.02913	182.9	-0.04194	263.4	-0.01591	100	0.023860

electrical machineries(35), motor vehicles(37), rail transport(41), and construction(44) where the respective impacts being 1150%, 1949%, -1710%, -2477%, 1088%, -1219% and -4014% respectively. This shows that other things remaining the same if the value added of the sectors had changed by the growth factor then the impact of this change would have fluctuated the energy costs by more than 1000%.

The impact of changes in technology/I-O coefficients was different from the overall trend in almost all the sectors of the economy. While the impact of the technology effect was 216.9% in rail transport(41), 197.2% in other chemicals(29), 114.6% in pesticides(27), and 102.6% in synthetic fiber and resin(28), it was significantly negative in sectors like construction(44) where the contribution was -677%, and in forest and logging(6) it was -173%. The other sectors with significant negative contribution were other food and beverages(14), electrical machineries(35), and other textiles(18). where the respective share being -159%, -116%, and -101%.

And finally the effects of interaction of value added and technology was not much significant except for some sectors like other food and beverages(14), woolen textiles(17), pesticides(27), synthetic fiber and resin(29), electrical & non-electrical machineries(34,35), motor vehicles(37), other transport equipments(38), other manufacturings(40), rail transport(41), and construction(44).

The above analysis of cost changes of energy had to be conducted using the relative price concept as input-output tables are not available in physical quantities which would have made the cost analysis more effective. However, as discussed in chapter 2, we can use effectively the I-O tables in value terms to study the cost analysis though it causes some errors in the result.

6.5. Summary.

This chapter was devoted to study the changes in the cost shares of energy inputs per unit of final demand for the Indian economy over the period 1979-80 to 1991-92. This analysis is based on the hypothesis that primary inputs are used in all industries whose output is needed directly and indirectly for production of an element of final demand. In this chapter first, we have studied the share of energy cost of goods and services for all the sectors over the years. Secondly, the changes in the cost shares of primary energy inputs over the period 1979-80 to 1991-92 were factored out into the effects of Changes in the technology(I-O coefficients), of changes due to the growth of value added, of changes in the composition of value added and into the effects of interaction factors. The total said period was divided into three sub-periods 1979-80 to 1984-85, 1984-85 to 1989-90,1989-90 to 1991-92, and the cost shares analysis was carried out for the three sub-periods as well as for the total period 1979-80 to 1991-92.

The analysis of final results indicated that though the primary sectors like cereals, cash crops, other crops etc were very less energy intensive i.e. the share of energy in the total cost is less. However, due to the energisation of agriculture sectors, the share was increasing for these sectors. Further, the results showed that energy played a crucial role in the manufacturing sectors of which the most important were plastic products, coaltar products, fertiliser, synthetic fibre and resin, iron & steel, non-ferrous metals etc. In transport services too the share of energy compared to total cost was high enough.

Further, the results showed that the energy cost shares in the Indian economy decreased in 1991-92 by 2.01% as compared to 1979-80. The sectors which witnessed a decline in their share were tea & coffee, iron ore, other minreals, sugar, woolen textiles, wood and wood products, paper and paper products, rubber products, pesticides, other chemicals, cement, other non-metalic mineral products, rail equipments, motor vehicles, electronics and

communication equipments, constructions, and other services, while the rest experienced an increase in their share of energy cost to the total cost over the entire period covered in this study.

Changes in the growth of value added was the most important factor affecting cost shares over the period 1979-80 to 1991-92. This factor constituted approximately -4730.5% of the total change during the same period. Changes in the value added constituted approximately 4229.03%. The effect of changes in the growth of value added and the composition of value added i.e. total value added effect was very high in sectors like electrical machineries, other food and beverages, forestry and logging, synthetic fiber and resin, leather and leather products, other textiles, khandasari and boora etc. while it was negatively high in sectors like other chemicals, motor vehicles, pesticides, woolen textiles.

The contribution of other components viz; the technology and interaction effect were not as significant as the composition of value added and the growth effect. The respective shares of the two components were 221.20% and 380.28%.

The three sub-periods, except the first sub-period, showed the same trend as the whole period. Compared to the entire period under study, the impact of interaction effect and the technology effect were very low during the sub-periods. As far as the individual components were concerned during the first three sub-periods the interaction effect helped in reducing the share during the first two sub-periods and a decrease in the third sub-period i.e 1989-90 to 1991-92. Similarly during the first sub-period a positive contribution was due to the value added effect whereas a negative contribution in the subsequent two sub-periods was experienced due to the change in the value added.

CHAPTER 7

SUMMARY AND CONCLUSION

7.1 The Perspective of the Study and Major Findings.

The main objectives of the study have been an indepth analysis of (1) the energy intensity of all the sectors of the Indian economy for the four reference years viz; 1979-80, 1984-85, 1989-90, and 1991-92 for which the Input-Output tables are available, (2) the structural decomposition analysis(SDA) of energy use changes i.e the decomposition of energy use changes into different components of change such as the growth effect, the changes in the composition of final demand, the changes in the technology, and the interaction factors, (3) and finally the energy cost shares to total cost and their decomposition into the respective sub-components over the period 1979-80 to 1991-92 in the Indian economy. The term primary energy intensity has been used to refer the total direct and indirect primary energy required to produce a single unit of output for the final demand sector. The analyses presented in this study have been carried out within the context of the static, open, Input-Output model. The Input-Output model is essentially a simplified model of production which takes into account the interdependencies among producing sectors in the economy. I-O tables provide the structure and the energy use related to such type of structure. Hence the I-O model is ideally suited for such studies.

For rapid economic development of India a comprehensive strategy of energy policy has to be evolved which needs efficient planning. The first requirement of such planning is to understand the energy required and energy intensities of all the sectors of the Indian economy. The present study is an effort in this direction.

This study has used the Indian I-O tables of 1979-80, 1984-85, 1989-90,- and 1991-92, as provided by the Planning

Commission of India, to provide a comprehensive analysis of energy intensities and their structural decomposition analysis of the total change between two given periods. The energy intensity and cost share analysis have been conducted for four periods, viz; 1979-80, 1984-85, 1989-90 and 1991-92 while the SDA has been carried out for three sub-periods viz; 1979-80 to 1984-85, 1984-85 to 1989-90, 1989-90 to 1991-92, as well as for the total period under study i.e. 1979-80 to 1991-92. Before these analyses were made, however, a number of adjustments were required to improve the comparability of the data. First, 1979-80, 1984-85, 1989-90, and 1991-92 I-O tables were rebased from current factor prices to 1984-85 factor prices. The year 1984-85 was chosen as the base year for prices in these exercises as it was the most normal year analysed for the purpose of the study. Next, certain sectors were aggregated to reduce these tables to a standardised 46 sector classification. In spite of these adjustments, a certain degree of incomparability remains and the results of these must be interpreted with appropriate caution.

The study analysing the inter-industry data of the period 1979-80 to 1991-92 apparently gives the looks of an exercise in economic history of the recent past. But it should be remembered that the latest I-O data available for the Indian economy is for the year 1991-92 which was published only in the year 1995. However, the orientation of the present study is to bring together and empirically test the methodology of analysis of structural change in the I-O framework by using the available Indian I-O tables. That is, the two strands viz; methodology and empirics run side by side throughout the study equally importantly. The results of the study are important in itself and also because of the importance of the said time vintage(i.e. 1979-80 to 1991-92) when the economy witnessed quick changes in the government at centre, oilshocks, and the advent of liberalisation. Besides these the importance of the said time period also emanates from the fact that it covers the fifth, sixth, and seventh plan periods of the Indian economy.

The first issue to be investigated in detail in this study was the issue of energy intensity of all the non-energy sectors of the Indian economy. Three exercises were performed in investigating this issue. In the first exercise, the individual and total primary energy intensity(TPEI) for all the sectors of the economy were calculated and discussed. In the second exercise, the percentage change in intensities of different sectors between three sub-periods viz; 1979-80 to 1984-85, 1984-85 to 1989-90, and 1989-90 to 1991-92 as well as the whole period i.e. 1979-80 to 1991-92 were analysed. The final exercise analysed the contribution of separate demand factors like private consumption, government consumption, gross investment, exports, and imports to the total primary energy use in the reference years.

The results showed that the sectors with high energy intensities were the manufacturing sectors like fertiliser, cement, iron & steel, non-ferrous metals, other non-metalic mineral products, leather and leather products, plastic products, rail transport and other transport services. On the other hand, the sectors with less energy intensity were communication, other services, wood & wood products, and primary sectors(except cereals). Further the analysis showed that the intensity had increased over the periods in sectors like agriculture(where it was due to the energisationof agricultural activities viz; use of tractors for tilling, use of pumpsets for lift irrigation etc), khandsari & boora, textiles, leather & leather products, rubber products, plastic products, pesticides etc. On the other hand, a fall in intensity was experienced in sectors like rail transport services, iron ore, other minerals, sugar, other food and beverages, wood & wood products, iron & steel, electrical machineries, etc. due to the conservation measures adopted by some of the manufacturing sectors and due to the improvement in technology in these sectors.

The next issue investigated in detail in this study was the issue of the structural decomposition analysis of energy change in the Indian economy and the components of such change. In this issue, the sources of change of energy requirements/use

were identified and measured. The sources of energy use change measured the contributions of the factors like changes in the I-O relations i.e. the technology change, average growth of final demand(or changes in the level of final demand), the composition of final demand and changes in the interaction(Interaction of changes in the composition of final demand and the change in the technology) factors to energy use changes. Here the interaction factor is further subdivided into interaction of growth and technology, and interaction of composition of final demand and the technology. Guill(1979) mentions that changes in I-O relations and changes in final demand are interrelated. In his words - 'although these elements of change are, in fact, interrelated, these interrelationship could not be identified within the context of the I-O model.' (Guill, 1979, pp 284) However, in our study we make it possible to measure this interrelationship between final demand change and I-O coefficient change. This component of energy use increase has been called the interaction factor. The final exercise under this issue analysed the contribution of separate final demand factors like private consumption, government consumption, gross investment, exports, and imports to energy use changes over the period under study.

The results showed that over the period 1979-80 to 1991-92 primary energy use had changed by 100211.1 Ttoe from 70971.23 Ttoe in 1979-80 to 171182.3 Ttoe. Due to changes in the level of demand the energy use increased by 71421.29 Ttoe while the increase in energy use due to changes in the composition of final demand, changes in I-0 coefficient, and the interaction effects were 10764.57 Ttoe, 11588.27 Ttoe, and 6436.96 Ttoe respectively. In terms of percentage the changes were 100.6%, 15.16%, 16.23% and 9.06% of the initial level of energy use.

Hence of all the components, average growth of final demand effect was the most significant factor affecting the increase in energy use. The growth of final demand component was analysed to show the effect on output assuming that the final demand of all sectors had been growing on an average growth rate and technology had remain unchanged. But in reality final demand of all

sectors does not grow at the average rate. That is, the final demand of some sectors increase above the growth rate while that of some sectors grow below the average growth rate. The impact of the deviations in final demand of sectors from the average growth rate, on energy use requirement was shown by the effect of the composition of final demand. The composition of final demand helped in reducing the energy use in sectors like other crops, animal husbandry, other mineral ores, khandsari and boora, other food and beverages, wood and wood products, coaltar products, synthetic fiber and resin, other non-metalic mineral products, non-ferrous metal products, non-electrical machineries. The average growth of final demand and the change in the composition of final demand showed the total impact of a change in final demand on energy requirement assuming that the technology had remained constant. These two components contributed approximately 82 percent of the total change in energy requirement during the period 1979-80 to 1991-92. Most of the remainder of total increase was contributed by the effect of change in technology and interaction effect of composition of final demand and technology.

While change in the composition of final demand reflects changes in the consumer's preferences, changes in the I-O relation reflects changes in the interdependencies among the producing sectors. The impact of changing I-O relations on outputs of industries in India has been small. This small impact of changing I-O relations has been noted in the studies of other economies also, and is usually explained as reflecting the offsetting effects of such factors as increasing specialisation, technological change and increased efficiency in the use of intermediate inputs. This finding is also evidence of the general stability of I-O coefficients of an economy. This stability is derived from the stability of the underlying technological relationships as well as the interdependencies among industries.

Although at the aggregate level the total requirement of energy associated with changes in I-O relations(assuming that the final demand had remained constant) appeared to change very little

over the period 1979-80 to 1991-92, there were marked shifts in the relative importance of different industries. Due to this effect there was a decline in energy requirement in sectors like food and beverage sectors(except khandsari and boora), fertiliser, pesticides, machineries except non-electrical and transport equipments, and services sectors. On the other hand, this change had increased energy use in primary sectors, cotton textiles, rubber products, non-electrical machineries, other transport equipments, and communication over the period 1979-80 to 1991-92. Some of these changes can be associated with specific energy policy initiatives by the Indian government. For instance, the subsidies given in the agriculture sector had encouraged the use of tractors, diesel and electric pumps as a result of which the technology effect had increased the energy use in these primary sectors. On the other hand, the replacement of coal locomotives by the more efficient diesel and electric locomotives induced in reducing the energy intensity in this rail transport sector.

The contribution of the interaction factors in the total change in energy requirement during 1979-80 to 1991-92 was small. The importance of this component is due to the fact that by separating this component we get the three main components instead of getting either overstated or understated effects of these components.

The analysis of different final demand categories showed that over the period 1979-80 to 1991-92, energy use increase in the Indian economy was largely due to the growth in the consumption demand(particularly private consumption expenditure) and investment demand. With the opening up of the economy the role of the foreign trade also increased over the years.

The last issue investigated in detail in this study was the issue of share of energy cost to the total cost and the factors responsible for any change in cost over the years. However, it should be noted that here energy sectors were considered as primary inputs like land, labour and were put in the value added quadrant. -There are very few studies so far which have

concentrated on the empirical investigation of this aspect of structural changes. The main reason for lack of such study has been the non-availability of I-O tables both at current and constant price levels. This study has investigated the changing energy cost share by factoring out into the effects of changes in the technology, of changes in the growth of value added, of changes in the composition of value added, and into the effects of interaction factor.

Analysis showed that over the period under study energy cost shares had declined by 2.01% as compared to the base year of 1979-80, which reflects the efficient use of energies. At the disaggregated level the sectors which were mostly affected are iron ore, other minerals, other transport. Out of the total change the growth in the value added was the most important factor affecting cost shares. This factor showed the effect on per unit costs of different sectors assuming that the prices of energy input had been increasing at an average rate. The change in composition of energy input showed in which sectors factor cost grew above average or below average and the impact of this on cost of different sectors. The growth of value added effect and the change in the composition of energy input components together contributed approximately -501.48% of the energy cost share change of most sectors, while the share of the change in the technology and interaction factors were 221.2% and 380.28% respectively.

Though it is beyond the scope of the study to examine detailed reasons for India's energy efficiency improvements, we can identify three macro-economic factors that appear to be primarily responsible for the energy efficiency increase in Indian economy between 1979-80 to 1991-92. The three factors are classified as (1) energy conservation programme; (2) improvement in macroeconomic performances; and (3) increase in Energy prices.

First, the improvements in energy efficiency were a result of India's energy conservation programmes. There has been a major shift in energy policy since the late seventies, from conventional complete devotion to increasing supply to a policy of placing equal emphasis on supply expansion and energy conservation, with

priority given to conservation in the short term. The government adopted a large number of administrative, financial, and economic measures in the eighties to reduce energy waste and promote energy efficiency in the industrial sectors, especially energy intensive heavy industries. Overall, these measures were highly successful and resulted in large energy saving, partly because India had been using energy very inefficiently until the 1970's. Therefore, there was a great potential for energy saving, much of which could be realized without a major capital investment and simply by restructuring energy use or reducing apparent waste.

Secondly, the improvement in energy efficiency were also a by-product of India's rapid economic growth and part of the overall trends towards higher productivity in the eighties. This trend was a result of the structural change of the economy from a backward agrarian economy to a modern industrialised one. Besides this it was accompanied by an expansion in production capacities and the addition of new equipments which were comparatively efficient than the exisiting capital equipments. More importantly, many measures that were aimed at increasing productivity and profitability also helped to save energy.

Finally, the improvement in energy efficiency were sometimes an enterprise's rational response to energy price increases. The Indian government raised the energy prices substantially and also introduced a different price system into the energy sector, which allowed energy products to be exchanged at different prices i.e. a state set prices for different sector like agriculture, industry, domestic etc. The prices for energy charged also varied with the level of use and time of use. These energy price difference provided some incentives for enterprises to reduce energy waste and improve the efficiency of energy utilisation. However, these incentives were limited, because despite the energy price increases, energy expenditures comprised a very small percentages of the total production cost in most sectors and were not that important in the overall scheme of production.

-

7.2 Limitations and Suggestions for Further Research.

This piece of study has atleast four major strengths for use in energy analysis. First, it integrates energy data with an input-output account and provides a unified framework for describing the relationship between energy, other factor inputs and other final products; consequently, this gives a framework for the relationship between the energy and the economy. Secondly, the framework includes all sectors of the economy and covers the entire energy production and consumption cycle. Thirdly, the model describes the economy as a system of interdependent activities, and enables analyst to trace inter-industry linkages and account for both direct and indirect energy uses; for example energy consumption in transport equipments sector, for instance, is the direct use of energy, while the use of other materials like iron & steel and plastic products in making transport equipments would be indirect use of energy, because energy is required to produce iron & steel, and plastic products. And finally, it helps in determining the extent and direction of impacts on aggregate energy use of technological, growth and final demand factors and hence provides information to the policy makers about the energy consequences of the past decisions, building a basis for future policies.

However, this study is also not free from limitations as other studies. First, we assume a linear production function or constant returns to scale, so failing to account for energy intensity changes caused by changes in the scale of production. Secondly, the study has used the standard, static I-O model for analysing the energy intensities and energy uses, the fundamental limitation of the model is that it represents the economy during a single period of time. Hence, it cannot describe the transaction of one state of the economy to another due to its static character. Thirdly, nor is it possible to analyse the effects of taxation(or any other effects of cost/prices) on the behaviors of producers and consumers, as the input-output relations are assumed fixed and substitution of inputs is not possible.

Finally, changes in the I-O flow coefficients were equated with technological change while in reality, technological change is a much broader concept. The impact of structural change on the domestic output of the industries and on their imports could also not be studied effectively. As such analysis requires further data of energy intensity of the imported goods which are not available for all the countries from which the goods and services are imported. Hence, it is assumed that the energy intensity of the domestic goods and services are identical with their foreign counterpart. This limitation may have distorted interpretation of the results of this study to some extent. Many data adjustments that were made for making I-O tables comparable add further limitation.

In spite of the above limitations the present study can help in presenting a comprehensive energy analysis in the production system of the Indian economy. It provides the possibility to get a first indication of the direction and order of magnitude of the consequences of changes in the economy or technology on use or cost shares of energy. The study also provides a good basis to evolve the energy policy for accelerated and balanced growth of the Indian economy. The study yields good material which can be used for further research.

It would be interesting to examine SDA of energy sectors in the Indian economy using the dynamic I-O framework. It will of course depend upon the availability of capital coefficient matrices of the Indian economy which would be compatible with the Hybrid units' transaction and coefficient matrices.

The analysis of changes in cost shares of primary inputs can be improved upon by separating the non-energy primary input vector into components like labour cost, capital cost, indirect taxes, and subsidies etc. Once this is done then we can analyse the substitution effects of factors, for instance between labour and energy, by adopting the KLEM approach developed by Chen & Rose(1990). However, this again requires additional database within the country which so far is not possible. Such an

analysis, if conducted, can provide more information about the SDA of energy cost in India.

The I-O coefficients are the links which transmit changes between industries. The links which themselves are related to technical changes and are thus an important central area for the analysis of energy changes. The present study gives information about changes in these coefficients and their impact on the development of the economy. This information could be used for concentrating further research on the relatively small group of the most important I-O coefficients.

Finally, the results of the study could be used for the international comparisons of the energy intensities and SDA of energy use changes of different countries whose economies are closely related by trade with India. This would increase the available information about interdependent changes between India and other countries.

Bullard,C.W. & Herendeen,R.A.(1975), "The Energy Cost of Goods and Services, *Energy Policy*,3, pp.268-278.

Bullard.C, Penner.P & Pilati," Net Energy Analysis: A handbook for Combining Process and Input-Output Analysis", *Resources and Energy*,Vol-1,No.3,pp 267-313,1978.

Bulmer Thomas,V.(1982), *Input-Output Analysis in Developing Countries*, (Wiley,New York).

Carter, A.P.(1967), "Changes in the Structure of the American Economy, 1947 to 1958 and 1962", *The Review of Economics and Statistics*, Vol.49, No.2.

------------(1970), *Structural Change in the American Economy*, (Harvard University Press, Cambridge).

------------(1974), "Application of Input-Output Analysis to Energy Problem," *Science*, Vol.184, April 19, pp. 325-329.

------------(1980), "Changes in the Input-Output Structure Since 1972", *Interindustry Review*, Data Resources Inc.(Summer).

Casler,S. & Hannon,B.(1989)Readjustment potentials in industrial energy efficiency and structure, *Journal of Environmental Economics and Management*,17, pp.93-108.

Casler.S and Wilbur.S.(1984)," Energy Input-Output Analysis- A Simple Guide", *Resources and Energy*, Vol 6, pp 183-201.

Central Electricity Authority (Various Issues), *Public Electricity Supply*, New Delhi.

Central Statistical Organization(Various Years), *Annual Survey of Industries*, Summary result of factory sectors.

Central Statistical Organisation(1990), *National Accounts Statistics, Sources and Methods,* Department of Statistics, Ministry of Planning, Government of India.

Central Statistical Organisation, *National Accounts Statistics,* Various Issues, Govt.of India.

Chandhok,H.L. and Policy Group(1990), *India Data Base,The Economy Annual Time Series Data* Vol I & II,Thomson Press India Ltd.,Faridabad.

Chen, C.Y. and Wu R.H.(1988), "*Sources of Change in Energy Use in the Taiwan Economy: 1971-1984,*" Report No. 763F1, Energy Committee, Taipei, Taiwan, R.O.C.

Chen, C. and Rose, A.(1990)," A Structural Decomposition Analysis of Changes in Energy Demand in Taiwan: 1971-1984," *The Energy Journal*, Vol. 11, pp. 127-146.

---------------------(1991), "Sources of change in energy use in the U.S economy 1972-1982", *Resource and Energy,* 13, pp. 1-21.

Chenery, H.B.(1960), "Patterns of Industrial Growth", *American Economic Review,* Vol.50.

Chenery,H.B.(1961), "Comparative Advantage & Development Policy", *American Economic Review,*Vol.51.

Chenery, H.B., Clark, P.G. and Cao-Pinna, V.(1953), *The Structure and growth of the Italian Economy,* (U.S. Mutual Security Agency, Rome).

Chenery, H.B., Shishido, S. and Watanabe, T.(1962), "The Pattern of Japanese Growth, 1914-1954", *Econometrica,* Vol.26, No.4.

Chenery,H.B. & Bruno,M.(1962), "Development Alternatives in an Open Economy : The Case of Israel", *Economic Journal* Vol.72.

Cornfield, J., Evans, W.D. and Hoffenberg, M.(1947), "Full Employment Patterns:1950", *Monthly Labour Review*, Vol.64, Jan-June.

Costanza, R.(1980), "Embodied Energy and Economic Valuation," *Science*, Vol.210, December, pp. 1219-1224.

Datt,R. and Sundaram,K.P.M.(1992), *Indian Economy*, S.Chand and Co.,Pvt. Ltd.,New Delhi.

Desai,Padma (1969), "Growth and Structural Change in the Indian Manufacturing Sector 1951-63", *Indian Economic Journal*, Vol.17, No.2, Oct-Dec. pp 205-233.

Dhawan,Sangeeta(1993), *Structural Change and Growth in Indian Economy*, Unpublished Ph.D. Thesis, I.I.T., Kanpur.

Dorfman, Samuelson, and Solow(1958), *Linear Programming and Economic Analysis*, McGraw-Hill, London and New York.

Economic Intelligence Service, *Indian Energy Sector*, Various Issues, Centre for Monitoring Indian Economy.

Feldman, S.F. and Palmer, K.(1985), "Structural Change in the United States: Changing Input-Output Coefficients", *Business Economics*, Jan.

Flaschel.P,(1982), "Input-Output Technology Assumptions and the Energy Requirements of Commodities", *Resources and Energy*, Vol.6, pp 359-389.

Forsell, O.(1988), "*A Decomposition Technique for Analysing Structural Changes in Production*", Discussion Papers on Structural Analysis of Economic Systems, Discussion paper No.8, Cambridge Growth Project, Department of Applied Economics, University of Cambridge, November.

Ghosh,A.(1958), "Input-Output Approach in an Allocation System", *Economica,* 25, No.97.

Ghosh,A.(1964), *Experiments with Input-Output Models,* Cambridge, The Univ.Press.

Gould, B.W., Kulshreshtha, S.N.(1986), "An Interindustry Analysis of Structural Change and Energy use Linkages in the Saskatchewan Economy", *Energy Economics,* July, pp. 186-196.

Govt.of India(1965), *Report of the Energy Survey of India Committee*, New Delhi.

--------------(1974), *Report of the Fuel Policy Committee,* New Delhi.

--------------(1979), *Report of the Working Group on Energy Policy,* New Delhi.

Govt.of India (1994), *Economic Survey,* 1993-94, Ministry of Finance, Economic Division.

Gowdy, J.M., and Miller, J.L.(1987), "Energy Use in the U.S. Service Sector: An Input-Output Analysis", *Energy - The International Journal,* Vol. 12, No. 7, pp. 555-562.

Gowdy, J.M., and Miller, J.L.(1991), "An Input-Output Approach to Energy Efficiency in the U.S.A. and Japan(1960-1980)", *Energy - The International Journal,* Vol. 16, No. 6, pp. 897-902.

Griffen,J.(1976), "Energy Input-Output Modelling", *Electric Power Research Institute*, Palo Alto, CA, November.

Guill, G.D.(1979), *Structural Change in the Soviet Economy,* Unpublished Ph.D Dissertation, (Duke University, Durham, N.C.).

Hannon,B.(1983) *Analysis of Energy Cost of Economic Activities:1963 to 1980*, ERG Document 316 (Urbana, IL, Enregy Resource Group, University of Illions at Urbana-Champaign).

Hatanaka, M.(1960), *The Workability of Input-Output Analysis*, (Fachverlag Fur Wirtschaftstheorie and Okonometrice, Ludwigshafen Am Rhein).

Hirshman,A.O.(1958), *The Strategy of Economic Development*, Yale Univ. Press, New Haven C.T..

Hwa Rang and Chia-Yen Ctten(1989), "Energy Intensity Analysis for the Period 1971-84 : A Case Study of Taiwan", *Energy - The International Journal*, 14, No.10, pp 635-641, 1989.

Hwkins,D.and Simon,H.A.(1949), "Some Conditions of Macro-Economic Stability", *Econometrica*, Vol.XVII.

Karasz,P.(1992), "Influence of Interindustrial Relationships on prices in Czechoslovakia", *Economic System Research*, 4, 4, pp. 337-384.

Kim, S.(1977), "An Interindustry Analysis of Petroleum Use in the United States: An Input-Output Approach", *Journal of Energy and Development*, Vol II, No. 2, Spring, pp. 310-320.

Kuene,R.E.(1954), "Walras,Leontief and the Interdependence of Economic Activities", *Quarterly Journal of Economics*, 68, August.

Leontief, W.W.(1953), "Structural Change", in W.W.Leontief et.al. *Studies in the Structure of the American Economy*, (OUP, New York).

Leontief,W.W.(1966), *Input-Output Economics*, OUP, New-York.

Lin,X. & Polenske, K.R.(1995), "Input Output Anatomy of Chinese Energy use Changes in the 1990s", *Economic System Research*, 7, 1, pp. 67-83.

Mahajan, V.S.(1983), *Energy Development in India- Issues, Trend and Alternatives,* edt., Deep and Deep Publications, New Delhi.

Matuszewski, T.I., Pitts, P.R. and Sawyer, J.A.(1964), "Linear Programming Estimates of Changes in Input Coefficients", *Canadian Journal of Economics and Political Science,* Vol.30.

Mehetre, M.G.(1990), *Energy Crisis in India,* Chugh Publication, Allahabad, India.

Miller,R.E & Blair,P.D.(1985), *Input-Output Analysis: Foundation and Extension* (Englewood Cliffs,NJ, Prentice-Hall).

Ministry of Petroleum and Natural Gas, Government of India(various Issues), *Indian Petroleum & Natural Gas Statistics,* New Delhi.

Ministry of Coal, Government of India(Various Issues), *Coal Directory of India,* Calcutta.

National Sample Survey Organisation(1991), Consumer Expenditure Survey Results (All India),NSS 44th Round (July-88-1991) June,89, *Sarvekshana,* Vol.XIV, NO.3, Issue No.46, Jan-March.

Office of the Economic Advisor(1993), *Wholesale Prices Indices, Commodity- group wise,* Oct.,Ministry of Finance.

Ostblom,G.(1982), "Energy use and Structural Changes", *Energy Policy,* 19,pp.21-28.

Pachauri, R.K.(1980), *Energy Policy for India,* Macmillan Co. of India Ltd, Madras.

Parikh, K.S.(1976), *Second Indian Issues:Energy,* Macmillan Co. of India Ltd, Madras.

Park,S.(1982), "An Input-Output Framework for Analyzing Energy Consumption", *Energy Economics,* 4, pp.105-110.

Peet, N.J.(1986), "Energy Requirement of Output of the New Zeland Economy, 1976-77," *Energy - The International Journal*, Vol.11, No. 7, pp. 659-670.

Perspective Planning Division(1981), *Technical Note to the Sixth Plan, 1980-85,* Planning Commission.

-----------------------------(1986), *Technical Note to the Seventh Plan, 1985-90,* Planning Commission.

-----------------------------(1995), *Technical Note to the Eighth Plan, 1992-97,* Planning Commission.

Proops,J.L.R.(1984), "Modelling Energy-Output Ratio", *Energy Economics,* 6, pp.47-51.

Rasmussen, P.N.(1956), *Studies in Inter-Sectoral Relations,* (North Holland Publishing Company, Amsterdam).

Richter, J.(1987)," Rise in Energy Prices and Industrial Response: The Austrian Case", A Paper Presented at *the IIASA Workshop on Energy, the Economy, and the Environment,* Laxenburg, Austria.

Ron Edwards and Ashok Parikh(1978), "Intensities of Energy Usage: An International and Intertemporal Comparison", *Energy Policy,* pp.66-75.

Saxena.K.K. and Rath.B(1991),"*Steel Industry in India and its Employment Multiplier Effect,* Himalaya Publishing House, New Delhi.

Sengupta, M.(1985), *Energy and Power Policies in India,* S. Chand and Co. Ltd, New Delhi.

Sevaldson, P.(1956), "Norway" , in *The Structural Interdependence of the Economy,* ed., T. Barna (John Wiley and Sons).

------------(1963), "Changes in Input-Output Coefficients", in *The Structural interdependence and Economic Development,* ed., T.Barna, (St. Martin's Press,Inc., New York.).

Shishido, S.(1957), *"Recent Input-Output Studies in Japan",* Memorandum C-6 of Standard Project for Quantitative Research in Economic Development, (mimeographed).

Skolka,J.(1989), "Input-Output Structural Decomposition Analysis for Austria", *Journal of Policy Modelling,*11, pp.45-66.

Staglin, R. and Wessels, H.(1972), "Intertemporal Analysis of Structural Change in the German Economy", in *Input-Output Techniques,* eds., A. Brody and A.P.Carter, (North Holland Publishing Company, Amsterdam, London).

Sterner,T.(1987), "Structural Change and Technology Choice of Energy Use in Maxican Manufacturing Industry 1970-81", *Energy Economics,* 7, pp. 77-86.

Tata Energy Research Institute(1994), *Teri Energy Data Directory & Yearbook 1994-95,* New Delhi.

Tilanus, C.B.(1966), *Input-Output Experiments, The Netherlands, 1948-1961,* (Rotterdam University Press).

Urata, S.(1988), "Economic Growth and Structural Change in the Soviet Economy, 1959-72", in *Input-Output Analysis:Current Developments,* eds., M. Ciaschini, (Chapman and Hall, London, New York).

Vaccara, B.N.(1970), "Changes Over Time in Input-Output Coefficients for the United States", in *Applications of Input-Output Analysis, Techniques, Vol.2,* eds., A.P.Carter and A.Brody, (North Holland Publishing Company, Amsterdam, London).

Vaccara, B.N. and Simon, N.(1968), "Factors Affecting the Post War Industrial Composition of Real Product", in *The Industrial Composition of Income and Product, Series in Income and Wealth,* No.32, ed., J.W. Kendrik, (National Bureau of Economic Research, Inc., New York).

Venkatramaiah, P. and Argade, L.(1979), "Changes in Input-Output Coefficients and their Impact on Production Levels", *Artha Vijnana,* Vol.21, No.1, March.

Watanabe, T.(1969), "Approaches to the Problem of Intercountry Comparison of Input-Output Relations:A Survey and Suggestions for Further Research", in *International Comparisons of Interindustry Data, Industrial Planning and Programming Series No.2,* (United Nations, New York).

World Development Report(1994), *Infrastructure for Development,* Oxford University Press, New York.

Wright, D.J.(1974), "Goods and Services: An Input-Output Analysis," *Energy Policy,* Vol.2, No. 4, December, pp. 307-315.

Wu, R.H., and Chen, C.Y.(1989), "Energy Intensity Analysis for the Period 1971-1984: A Case Study of Taiwan," *Energy - The International Journal,* Vol. 14, No. 10, pp. 635-641.

-----------------------(1990), "On the Application of Input-Otput Analysis to Energy Issues," *Energy Economics,* January, pp. 71-76.

Date Slip

This book is to be returned on the date last stamped.